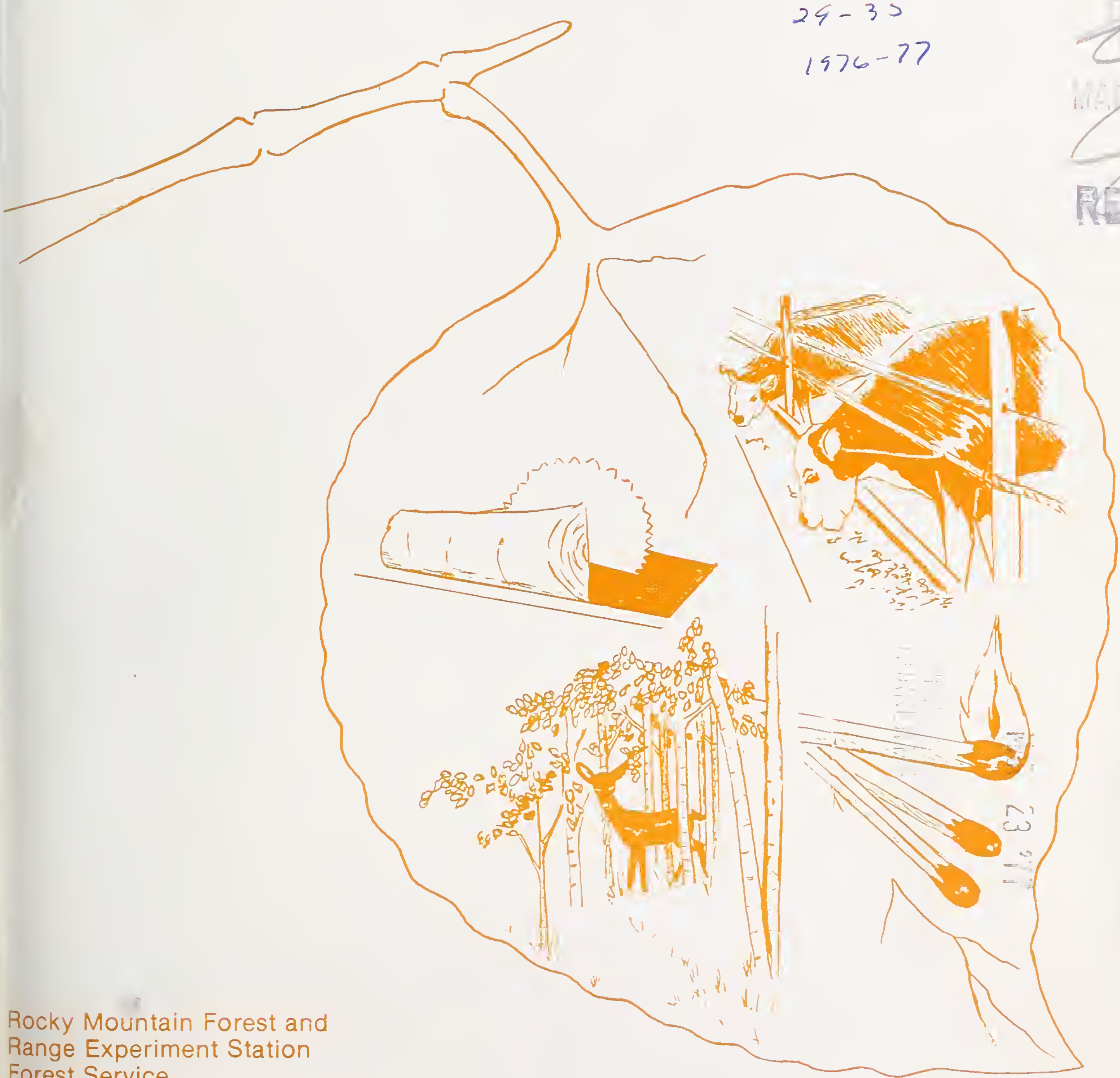
Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains

Proceedings of the Symposium

September 8-9, 1976
Fort Collins, Colorado



Rocky Mountain Forest and
Range Experiment Station
Forest Service
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Acknowledgments

The symposium sponsors agreed early last year that such a meeting would be a fitting way to sum up the results of their joint 18-month study of Rocky Mountain aspen utilization opportunities. It could not have materialized, however, without the generous support and participation of a number of other organizations and individuals. I want to extend my warmest thanks to everyone who helped make this venture succeed.

For developing the program and recruiting the speakers and moderators, I am indebted to the Program Committee headed by Eugene M. Wengert, now of Virginia Polytechnic Institute and State University, but formerly with the Forest Products Laboratory, stationed at the Rocky Mountain Station.

Many people in the State and Private Forestry and Research Branches of the U.S. Forest Service contributed significantly by notifying potentially interested organizations and individuals and publicizing the symposium in the press, by arranging for pleasant and commodious facilities, and by editing and publishing these proceedings. William B. Wilcox of the Colorado State Forest Service was particularly helpful in making arrangements.

In addition to the individuals who served on the planning and implementing committees, I want to recognize the following organizations that cooperated with the sponsors in presenting the symposium:

Colorado State Forest Service

Colorado State University
College of Forestry and National Resources

New Mexico Department of State Forestry

State of Utah Forestry and Fire Control

USDA Forest Service, National Forest Systems, Regions 2, 3, and 4

USDA Forest Service, State and Private Forestry, Regions 2, 3, and 4

Finally, let me express my deepest appreciation to each and every speaker for his informative presentation. Quick publication of these proceedings--a major planning goal--depended on the cooperation of the authors in preparing their papers in final form, ready for photo-offset reproduction. The moderators also deserve credit for providing a climate conducive to productive exchanges. The discussions during the symposium were unusually active for so large a group.

Because of the genuine interest and active participation of all of you who attended, the success of the symposium exceeded my expectations. I truly hope that it also met yours.

HAROLD E. WORTH
Symposium General Chairman

[The exceptional culinary products baked by Hal's wife Phyllis also contributed greatly to the congeniality of the coffee-break discussions.--Ed.]

Foreword

The sponsors take great pleasure in making available these proceedings of the symposium on utilization and marketing of Rocky Mountain aspen, held in September. Our intent in organizing the symposium was to explore aspen product potentials as they relate to more intensive management of this species in the West. The symposium also provided an early opportunity to share results of an 18-month research assignment on Rocky Mountain aspen utilization, carried out by Dr. Eugene M. Wengert and supported jointly by the symposium sponsors.

From your response, we are confident that the symposium has contributed significantly to a common understanding of the problems associated with aspen utilization. We also believe it will serve as a springboard for future action to maintain and improve the aspen timber type in the Rocky Mountains.

Aspen forests of the Rocky Mountains have been a much appreciated, but generally neglected, resource. The fall color of aspen groves is an awe-inspiring scenic attraction. Their value for wildlife browse and cover is widely recognized, as is their ability to stabilize soils. Further, wood and fiber products made from aspen contribute uniquely to National needs. In short, aspen forests are a recognized asset to the Rocky Mountains and the Nation as a whole. Unfortunately, there is no assurance that we will continue to benefit at the desired level from this species, unless ways are found to manage it more actively.

Most foresters agree that the key to succesful aspen management in the Rocky Mountains is in manipulating the age and density of stands. Nature does this through disease and fire, over long periods of time, and periodically most aspen stands revert to coniferous forests. Since such uncontrolled natural events are no longer "socially acceptable," man is challenged to simulate their overall effects by intentionally removing timber of various forms and age classes to provide residual stands of the desired composition. But such harvesting is practical only if materials to be removed can be satisfactorily disposed of, which suggests a need to create productive and economic uses. This brings us back to the motivation behind this symposium.

The purposes were to bring available information on western aspen utilization into focus, and to explore possibilities for improving resource management through increased marketing opportunities. Without the promise of economic return, the door will be nearly closed on implementing management options to produce the desired aspen forest types.

Interest and enthusiasm evidenced by symposium participants through their attendance, papers, and discussion convince us that the subject was important and timely. We hope these proceedings will help highlight for participants and others what we now know about utilizing aspen, and what must yet be learned. We also hope that the proceedings will serve as a companion document for the forthcoming publication, Aspen: Ecology and Management in the Western United States, by John Jones and Kimball Harper, to be published next spring as a Rocky Mountain Station Research Paper. That report will summarize the biological knowledge required for adequate aspen management and the information needed to design further silvicultural research.

Harold E. Worth, Symposium General Chairman
Rocky Mountain Forest and Range Experiment Station

THE SYMPOSIUM

SEPTEMBER 8-9, 1976

Panel I.

Perspectives On Rocky Mountain Aspen Resource

Moderator: Eugene M. Wengert

Extension Specialist
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia

Perspectives On Rocky Mountain Aspen Resource: An Overview[1]

Eugene M. Wengert[2]

Abstract.--The Rocky Mountains have more aspen sawtimber than the Lake States, yet the species is not managed for the fiber it can supply. Increasing demand for wood fibers and increasing management activities will result in increasing utilization of aspen.

INTRODUCTION

Aspen (Populus tremuloides Michx.)[3], also commonly called "popple", "poplar"[4], "quaking aspen", and "quaky", is the most widespread species in North America, stretching from Mexico to the Arctic Ocean, Maine to California (Fig. 1). The range is controlled by adequate moisture levels and cool summer temperatures.

Important commercial concentrations of aspen exist in Northeastern United States, the Great Lakes area, central portions of Canada, and in the Central Rockies. In the Central Rocky Mountains, commercial aspen is generally confined to elevations between 7,000 and 11,000 feet. Although aspen is widely distributed in the Rockies (Fig. 1), important commercial sawtimber concentrations are limited to North central and Southwestern Colorado, Northern New Mexico, and South central Utah.

1/Paper presented at the symposium Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

2/Extension Specialist, Forestry. Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

3/In some geographic areas "aspen" includes P. grandidentata Michx., and P. balsamifera L. (commonly called big-tooth aspen and balsam poplar respectively). In the Rockies, the only significant aspen species is P. tremuloides Michx.

4/Poplar in the eastern U.S. lumber trade can also refer to yellow-poplar (Liriodendron tulipifera L.).

Aspen is extremely important in the overall resource/land use picture in the Rocky Mountains. It is extremely beneficial for watershed improvement, soil building, and wildlife forage, as well as for recreational uses and scenic beauty. As a generalization these preceeding benefits are the management objectives for the species. Unlike the Lake States, then, the aspen resource in the Rocky Mountains is not managed directly for the fiber it can potentially provide for wood products. And yet, aspen in Colorado has an annual volume increment of 120 board feet per acre (Miller and Choate 1964), well above ponderosa pine, but below Douglas fir. Further, the Rocky Mountains have more sawtimber volume (DBH 11-inches and greater) than the Lake States (Table 1). Colorado has 17% more sawtimber volume than Michigan, 32% more than Minnesota, and 49% more than Wisconsin.

In terms of acreages, the Rocky Mountain States have 4.1 million acres of aspen-type, commercial forest land (CFL)(Green and Setzer 1974).

State	Aspen-type Acreage (Acres)	Commercial Forest Land in Aspen-Type (%)
Colorado	2,288,900	25
Utah	1,105,300	31
New Mexico	346,100	6
Wyoming	187,900	6
Arizona	89,900	2
Idaho	60,200	0
Montana	44,700	0
Nevada	6,500	5
TOTAL	4,129,500	

This is only 31 percent of the aspen CFL in the Lake States (Minnesota, Wisconsin, and Michigan).

However, aspen-type occupies a significant part of the commercial forest land in the Rocky Mountains. In Colorado, aspen-type acreage is 25 percent of the total commercial forest land; in Utah, 31 percent (occupying more land than any other forest type); and in New Mexico, 6 percent. Sixty-five percent of this aspen-type acreage is public land.

In recent years the importance of managing aspen and maintaining the species as an important component of our Rocky Mountain forest has been recognized.

Indeed, many of the benefits obtained from the species cannot be achieved without proper management.

Table 1.--Net volume of aspen growing stock and sawtimber on commercial forest land, 1970

	GROWING STOCK		SAWTIMBER	
	Aspen Volume	Aspen Volume Compared With Total Growing Stock Volume	Aspen Volume	Aspen Volume Compared to Total Sawtimber Volume*
	million (cu.ft.)	(%)	million bd.ft. (1/4-in. INT rule)	(%)
		ROCKY MOUNTAINS		
Colorado	1,807.4	15	3,142.4	8
Utah	1,038.5	22	1,574.4	7
New Mexico	600.9	9	1,475.3	11
Arizona	226.1	5	678.7	3
Wyoming	170.3	4	199.4	2
Idaho	68.6	0	117.0	1
Montana	51.4	0	74.1	0
Nevada	12.2	5	21.8	
TOTAL	3,975.4		7,283.1	
		LAKE STATES		
Wisconsin	2,159.5	20	2,109.3	11
Michigan	2,257.1	15	2,684.0	9
Minnesota	3,018.2	31	2,387.9	18
TOTAL	7,434.8		7,181.2	

Sources: Green and Setzer (1974) for RM data
Chase *et al*. (1970) for Michigan data
Spencer and Thorne (1972) for Wisconsin
Spencer (1968) for Minnesota

*Includes softwoods 11" DBH and greater

Figure 1.--Aspen distribution in North America (Little 1971).

In the past an important "natural" aspen management tool was wildfire--young aspen, arising from root sprouts, would quickly reforest a burned conifer area. As these aspen sites matured, they frequently would naturally revert back to conifers in 100 to 200 years. However, with the control of wildfire (and with the present cutting and logging practices in the conifers that do not open up large areas) conditions are often unfavorable for large scale aspen regeneration (Schier 1975). Yet, as stated above, it is important to keep the aspen forest as part of the total Rocky Mountain forest in widespread locations. The management tool that is available to do this is aspen wood utilization. By logging aspen in small, cleared areas, the aspen will regenerate and the type can be maintained where and when desired (Jones 1975).

With this rosy picture, it might seem as though the resource is waiting to be tapped. Yet annual usage is below 10 million feet. Frequently, the lack of markets or availability of better species (i.e., conifers) is blamed for this lack of utilization. Indeed this may be part of the problem, but the resource itself also causes some difficulty:

a) 2/3 of the aspen sawtimber is between 11 and 15 inches
b) decay becomes significant on poor sites well before commercial size is attained and on good sites shortly after sawtimber size is reached.
c) aspen is generally scattered in large and small groves interspersed among the conifers increasing procurement and handling costs.
d) other uses or demands on the resource preclude harvesting
e) the form of the tree increases harvesting, transportation, and milling costs.
f) snowfall limits accessibility to three to six months per year

The impact of these items should not be underestimated. Some of these will be discussed in subsequent papers in more detail.

The regional and national demands for fiber also may affect the resource and its utilization...and vice versa. The U.S. Forest Service's analysis, "The Outlook for Timber in the United States," indicates increases in per capita consumption of wood (both in solid forms such as lumber, and in reconstituted forms such as paper) as well as increases in population. The demand in 1970 was 12.7 billion cubic feet; the projection for 2000 is 23 billion. It's projected that roundwood hardwood removals in the Rocky Mountains will increase from 3 million cubic feet in 1970 to 76 million cubic feet by 2000. Of course, these are only projections but they do indicate the increasing utilization pressure on the resource. And aspen will become a more acceptable species, I believe, because

(a) the industry is cutting and processing more small diameter timber
(b) fiber or particleboard mills will become established in the region
(c) landowners will become more aware of the management needs of the species.

In summary we have a significant aspen resource in the Rocky Mountains. Over the next few decades utilization will become an important management tool for maintaining the resource and its benefits.

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Perspectives On Rocky Mountain Aspen Resource: Forest Industry[1]

Percy D. Gray[2]/

Brief History of the Splint Plant in Mancos

In 1944 or 1945 a timber cruise was made in the Mancos Ranger District on the aspen resources. This study was made by an assistant range from the Delta District--a man by the name of Charles Town, now 80 years old and still living in the area. Though retired, he remains interest in the results of the cruise and, of course, the welfare of the match splint plant located in Mancos, more or less as a result of his cruise study. He recalls a man by the name of E. A. Snow was supervisor of the San Juan Forest at that time.

The plant was constructed in 1946 or 1947 by Berst Forster Dixfield Company, Divison of Diamond Match Company. Plant began operation in 1947 and shipped splints to Dixfield, Maine and Oswego, New York. Pocket and regular penny boxes of splints were the only square splints produced at this time. Operation was stopped in 1949 because of a large amount of splints.

Plant resumed operation again in 1951 under the name of Diamond Match Company. The Mancos plant was the first to produce the square kitchen match, and these splints were shipped to Oshkosh, Wisconsin, and Chico, California.

Diamond sold the Mancos Plant to Ohio Match Company, Division of Hunt Foods and Industries, on May 1, 1960. Two of our present employees helped on the construction of plant, and others have been with the plant since it started operations.

Plant Location and Processes

The life of the wooden Ohio Blue Tip match you strike today began 80 years ago in the mountains of Colorado when a little aspen tree took root in the rich soil among the rocks. The tree grew until it reached a height of about 40 feet and became mature for harvesting under the planned forest programs of today.

At the Ohio Match sawmill in Mancos, Colorado, the tall, white aspen is transformed into match sticks. The tree is cut into bolts about two feet long, the bark is stripped off, and the bolts are fed into a veneer lathe which cut around and around their circumference (just like you'd peel an apple) and turns them into thin, continuous sheets of wood.

Next a larger chopper slices the sheets into thousands of precision made sticks. The sticks then pass through a liquid (ammonium phosphate solution) which treats them so they won't glow after being extinquished, and they are ready for delivery to the factory at Wadsworth, Ohio.

We have recently completed 2,560 days without a lost-time accident in our Mancos Plant--nearly six years.

Quality

Since the Consumer's Safety Commission in Washington has focused attention on the match, we have furnished information and help towards setting new safety standards. This has proved frustrating to us in Mancos at times because, in effect, break strength standards were raised from six pounds to eight pounds four ounces on kitchen splints while aspen harvesting utilization standards were raised to one-third good on a saw log base rather than a match bolt base on the United States Forest Service aspen sales. You all know what kind of a problem then is presented when we try to chuck a punky and rotten centered match bolt in our veneering lathes.

Silvicultural requirements on our present aspen sale are costing us about eight dollars slash reduction on a program that I question the value of. I feel industry is paying for a lot of experimental unknowns. With spiraling

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[1]/Paper presented at the symposium Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

[2]/Plant Manager, Ohio Match Company, Mancos, Colorado

costs, the economics of producing a product such as we do has become a major thing. Check the price of a box of matches at your friendly grocer--it still is very reasonable.

Economics

Environmental and aesthetic costs are proportional much too high at this time, weighed against the end product. We are dealing with a low value timber resource and installing high priced hardware in trash fences and a road system much too high in standard to warrant the end product.

Road costs now are seven to eight dollars for our timber resource valued at one dollar!

Only fifty per cent of the logs arriving in our log yard can be utilized in our end product. The cull types arriving must be sold to other users such as the excelsior and the mine prop and furniture people such as Western Timber and Development Company that broker this fifty per cent we can not use. We are very fortunate to have Western Timber and Development working so closely with us in this utilization.

Changing harvesting standards on the new aspen sale contracts do not recognize the match bolt standard that this plant was built and operated on in Mancos since its conception. Aspen sales recently have only been presented on a saw log basis. For those of you who have heard the match bolt standard, it is as follows:

A match bolt shall be considered as 24 inches long and is merchantable if it contains no more than 8 inches of surface length of defect determined by adding the sum of the knot diameters, length of seams, dry faces, and decay: Provided, that rot of any kind in the center of a bolt shall cause the bolt to be classed as unmerchantable if it exceeds 2 inches in diameter in bolts less than 10.0 inches in diameter, or if it exceeds 4 inches in diameter in bolts 10.0 inches and larger in diameter. Vs. our well known saw logs standards using a "1/3 good" standard.

Designated cutting at that time was as follows:

All live aspen trees 10.0 inches and larger in diameter at a point 4-1/2 feet above the ground, merchantable as defined, are designated for clear-cutting: Provided, that cutting in aspen stands 10 acres and larger in area which contain an average of less than 1,500 board feet of merchantable timber per acre will not be required.

Aspen In Perspective In Colorado[1]

Robert S. Mathison[2]

Abstract.--The distribution of the aspen tree in Colorado and Wyoming is significant. To relate aspen in perspective to other species of trees is to realize that 1/3 of the forested land in Colorado supports aspen. The potential as a timber resource is appreciable. Approximately five million board feet are harvested annually in Colorado from a total harvest of 285 million board feet, all species.

Good Morning - I am excited about being involved in this symposium; not so much for what I'm going to contribute but rather, the agenda tells me that I am going to experience two days with many interesting panel discussions. I will present data on the Aspen's vastness, that is to say, area, productivity, and utilization. This will be a part of the many parts that go into making up the total story that will be developed over the next two days.

Aspen causes a migration of the urban residents to the mountains each fall, to view the aspen in color. For a week or ten days each September, the spectular beauty of aspen is the subject of pictorial specials on TV and in the newspapers. Even transcontinental airline passengers can appreciate aspen in color as almost one-third of the forested land in Colorado turns to gold. It is truly beautiful.

Extent

In spite of short-lived popularity each fall, for the balance of the year, aspen is virtually ignored. Its potential as a timber resource is seldom discussed. It is therefore very timely and critical that many of us acquire an understanding of the aspen resource. Time is becoming critical for many of our aspen stands in that they are beginning to deteriorate, and this deterioration will increase significantly in the next 40 years.

Of the nine million acres (CFL & NON-CFL) support aspen. Two-thirds of this is on National Forest lands. The Shoshone, Bighorn, and Medicine Bow National Forests in Wyoming contain an additional one hundred thousand acres of aspen. Our aspen stands are classified into the unregulated[3] land classification component, with the exception of 2,500 acres on the San Juan National Forest which is in the standard and special component (268,900 acres of aspen type). The preponderance of our aspen stands are in Colorado; therefore, the balance of this presentation will be limited to the aspen resource in Colorado.

Productivity

Because aspen stands often contain a high proportion of small, crooked trees and are highly susceptible to a variety of diseases, aspen has sometimes been considered a weed species. Frequently overlooked is the capacity of this species to produce sawlog-size trees in a relatively short time: 250,000 acres of aspen are classified as capable of producing 85 cubic feet (approximately 390 board feet) per acre per year. Only the spruce-fir type has comparable productivity. Although aspen may be found at both the upper and lower limits of tree growth, the most productive sites are located on Western slope forests between 7,000 and 9,000 feet in elevation. Aspen also shows excellent growth where it occurs in varying mixtures with spruce and fir at elevations above 9,000.

1/ Paper presented at the Symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

2/ Silviculture and Timber Management, USDA Forest Service, Region 2, Lakewood, Colorado.

3/ Forest lands suitable and available but not organized for timber production under sustained yield principles, where timber harvest is permissible but not a goal of management.

Perspective

Of the nearly 3 million acres, less than a half million acres of the aspen type are in the sawtimber size class. Therefore, even though aspen occupies almost a third of the forested area, it represents only 15% of total commercial cubic foot volume and 6% of the commercial board foot volume. The volume of this resource in Colorado is 3.7 billion board feet or 1.9 billion cubic feet.

I have already mentioned the value of the aspen resource for recreation and esthetics. In addition, the aspen type produces abundant forage for domestic livestock and wildlife. Its value as a timber resource has been barely tapped.

Utilization

About five million board feet are harvested annually, which is approximately 2% of Colorado's harvested volume. The majority of this volume is utilized as matchstock. The balance is manufactured into boards, paneling, excelsior, and speciality products. During the Viet Nam conflict, for example, a plant at Hotchkiss utilized two million board feet annually to manufacture disposable pallets. One contributing factor to this low level of utilization is the relative low quality. Many stands consist of small trees of poor form. The horseshoe fungus is a serious pathogen of the species. Even in its incipient stage, this disease materially reduces wood strength.

Generally, disease is more prevalent in overmature aspen stands just as it is in other species. Much of the aspen existing today invaded areas disturbed by extensive fires, mining, ranching, and railroad building activity in the late 1880's. These stands are now at or beyond the rotation age of 80 years. As stated earlier, without management (utilization through harvest or controlled burning of stands), the older aspen stands will continue to deteriorate and many will be invaded and occupied by the more tolerant conifers or by shrubs and grasses.

A Projection

The 2,386 million acres of aspen in Colorado are a resource widely used for esthetics, recreation, wildlife, and grazing of domestic livestock; none of which will significantly aid in perpetuating the stands. The suitability of our aspen stands for these purposes will continue to diminish as our stands continue to deteriorate and are replaced by other vegetation.

The utilization of aspen for wood products will increase significantly over the next 10-20 years as research findings are implemented and resulting consumer demands rise.

These increased demands for aspen as a wood product should peak in terms of time as our aspen stands disappear from the scene.

Aspen Resource In The Southwest[1]

Darrell W. Crawford[2/]

Abstract.--There is a relatively large source of unused aspen in the Southwest. If markets can be developed, there are challenging opportunities to utilize more of this fiber. Most aspen in the Southwest is classified in the marginal component because of steep slopes, accessibility and low market values. To meet the logging constraints of this component is a real challenge to prospective purchasers. However, commercial opportunities are feasible on the Carson, Santa Fe, Apache and Kaibab National Forests.

The aspen type in the Southwest is extremely valuable for aesthetics and wildlife habitat, but to maintain the type and provide habitat harvesting is essential. The acres of aspen type are declining because of the absence of fire and conifer understories taking over the site. Because of past tree selection and present shelterwood cutting methods the occurence of aspen in ponderosa pine and mixed conifer is also on the decline.

Maintaining the aspen type and managing for its highest values are dependent on being able to harvest aspen and harvesting aspen is dependent on having a market for products. Therefore, the critical factor in the Southwest is development of aspen fiber markets.

Aspen (Populus tremuloides) grows under a great variety of conditions and can be found in small stands on most National Forests in the Southwest. In the Southwest Region of the U. S. Forest Service (New Mexico and Arizona) there are approximately 180,000 acres of pure aspen stands and 350,000 acres of mixed conifer stands that include aspen. This 530,000 acres represents approximately nine percent of the commercial forest lands in the Southwest.

Using the Forest Service Standard timber Land Classification the 180,000 acres of pure aspen stands are classified as twelve percent standard component, three percent special component, eighty-one percent marginal component and four percent unregulated component. The majority of aspen is placed in the marginal component (81%) because of steep slopes, poor accessiblity and low market value.

In the Southwest the highest value placed on aspen is for its contribution to the scenic beauty of the landscape. Aspen is a very aesthetically pleasing tree and contributes greatly to the variety of the forests. The velvet green leaves in spring, bright yellow leaves (at times tinged with red) in the fall and white bark that contrasts with that of the conifers is vital to the scenery in a Region dominated by pure conifer forests. This high value placed on the scenic qualities of aspen does not mean that it cannot be harvested and utilized to benefit man. In fact, just the opposite, it must be harvested to obtain regeneration and maintain healthy stands that will provide the aesthetic values in the future.

The distribution of aspen within the Southwest Region finds about seventy percent

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1/ Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

2/ Supervisory Forester, U. S. Forest Service, Region 3, Timber Management Staff Unit, 517 Gold Ave. SW, Albuquerque, NM 87102

of the stands in Northern New Mexico on the Carson and Santa Fe National Forests, nine percent in central and southern New Mexico and 21 percent in Arizona distributed about equally on the Apache, Coconino and Kaibab National Forests. Commercial harvest of aspen is considered economically feasible in Northern New Mexico, on the Apache portion of the Apache-Sitgreaves National Forest and on the North Kaibab portion of the Kaibab National Forest. Each of these units requires separate discussion as they do not lend themselves to one commercial operation because of distance separating them.

The Carson and Santa Fe National Forests of Northern New Mexico offer the greatest commercial potential. There are 121,000 acres of aspen type of which approximately one half is presently accessible. The annual potential yield is 6.5 MMbf of sawtimber and 4,600 cords of poletimber. The stands are of average quality with considerable heart rot at the lower elevations. The volume is primarily located in the marginal component because of logging constraints on steep slopes and no existing markets. There are small amounts of studs, wall paneling, excelsior and corral poles being produced. There is sufficient aspen to support a small sawmill operation, but the future utilization of the aspen potential in Northern New Mexico probably depends on the development of a pulpwood market.

The Apache portion of the Apache-Sitgreaves National Forest has 15,100 acres of aspen type classified in the marginal component. Most of these acres are of good quality aspen in the seventy year age-class. There has been virtually no market for aspen on the Forest, but inquires have increased on the availability of aspen for poles, shakes, excelsior and pulpwood.

The long term Colorado Plateau Pulpwood Sale (terminates in 1989) purchased by Southwest Forest Industries provides for 252,000 cords of aspen as an optional species. However, the Southwest Forest Industries pulpwood plant at Snowflake, Arizona is presently not set up to process aspen. As the demand for fiber increases, the purchaser may become more receptive to the aspen option. A potential for Aspen sawtimber harvest on the Apache National Forest does exist, but presently the annual potential yield is established at 5,300 cords.

The Kaibab National Forest has 15,200 acres of pure aspen (97% is on the North Kaibab) of which 14,200 acres are classified in the standard component, available, accessible and of average aspen quality. The annual potential yield is 4.8 MMbf or 10,977 cords of sawtimber and 8,938 cords of poletimber. The present outlook is that aspen is extremely valuable for aesthetics and wildlife, must be harvested in order to manage for aesthetics and wildlife, and that aspen will become an important producer of wood fiber. Aspen represents nine percent of the wood fiber on the North Kaibab, but no market presently exists.

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Carson Timber Management Plan
Approved April 4, 1975

North Kaibab Timber Management Plan
Approved June 29, 1972

Santa Fe Timber Management Plan
Approved July 10, 1975

Aspen Potential — A Land Manager's Viewpoint[1]

Bruce B. Hronek[2]

From a land manager's viewpoint, the management of aspen has been lacking. However, the potentials of aspen as a viable and meaningful species that will contribute much to the forest environment and economics is both possible and practical.

Aspen, as a tree or part of an ecotype, has always been a very interesting subject for discussion among land managers. We typically like to discuss its merit as an overstory for wildlife, as a viable area indicating soil conditions conducive to good grazing, as a scenic landscape in its mottled patterns, as an indicator of stable watershed conditions, and as a place for people to enjoy recreation experiences. But, like the weather, few are concerned about management direction, economics, or its potential. What most Western and Rocky Mountain land managers do not want to talk about is management of aspen ecotypes for their multiple benefits, including wood products for a growing economy. Many who talk of managing aspen for the totality of its ability to provide both a viable forest environment and as an economically feasible wood are generally considered heretics or, at best, troublemakers.

Research and other literature reviews seem to indicate we may have been going in the wrong direction in managing aspen, especially in the areas along the Wasatch Front in Utah, where watershed policy has protected these areas from cutting and intensified all fire protection. We are now getting invasion of the sites by conifer types and replacement, to a great extent, of what were traditional aspen stands by other species. The aspen is getting old, generally over 80 years of age, with well defined sighs of deterioration (Alder 1970).

1/ Paper presented at the symposium Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

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Aspen is the most widespread deciduous type in the Western United States. It dominates over 6.3 million acres of forest in the Rocky Mountain-Great Basin Region. The majority of this acreage is found in Colorado (over 3.0 million acres) and Utah (over 1.3 million acres). Wyoming and southern Idaho each have over one-half million acres; and New Mexico, 0.4 million acres. Nevada, Arizona, and western Montana make up the remainder (Choate 1965) (Green and Setzer 1970).

A few facts should be brought out concerning the management aspects of aspen and some of the things we should be concerned with in our establishment of aspen policy.

Aspen is esthetically desirable. The texture and variation in aspen stands make it desirable both as a foreground and a background vegetation. The various shades in the fall make it especially pleasing in a landscape. With few exceptions, it has esthetic characteristics superior to other tree species native to the Rocky Mountain-Great Basin Region.

Aspen grows rapidly and is one of the fastest growing tree species in the Intermountain West. The most common method of reproduction is through root sprouting, thus reducing costs and the uncertainty of regeneration (Brinkman and Roe 1975). Cutting appears best during dormant periods because of better opportunities for sprouting (Strothmann and Zasada 1974). Rotation is 60 to 80 years, as compared to 120 years for most other species in the Great Basin.

Aspen is fire resistant. Conifers, particularly white fir, are flowly replacing aspen in many areas. Conifer is especially susceptible to large fire situations (Gurell and Loope 1974). Replacement of aspen with

conifer is resulting in increased fire hazards, especially along those critical watersheds that are so vital to the Wasatch Front communities. Fires that do occur naturally in aspen appear to be smaller in size than conifer fires.

Aspen is also an effective watershed cover. Aspen, through canopy intercession and general abundance of understory vegetation, provides for very effective watershed conditions. The flood history of aspen stands compared to conifer stands indicates aspen is a superior species. Studies show aspen as using less water than conifer on the same site on a year round basis (Johnston and Doty 1972).

Aspen creates a superior wildlife habitat. Wildlife biologists indicate aspen provides an optimum habitat for a variety of small and large animals. It is superior to conifer in the variety of wildlife feeding and nesting in its environs (Morgan 1969).

Most aspen stands provide high forage production. The available vegetative cover under the aspen on the Uinta National Forest in Utah averages 2,100 pounds dry weight per acre, compared to 300 pounds dry weight per acre for conifer. This information is derived from range environmental analysis data. The obvious ramifications of understory production lie within the needs of the livestock industry and the National emphasis in red meat production.

An objective view of aspen must also point out some limitations. The species' size and height characteristics have resulted in little interest from the timber industry and little public acceptance of aspen as a viable building material. The exception is pulpwood use in the Lake states. A limited, local market for aspen as mine washers and pallet materials is developing in Utah, but only a relatively small demand exists at this time. Its susceptibility to bark carving and lack of resistance to disease makes it somewhat undesirable as a recreation site overstory.

Some misconceptions concerning aspen should also be dispelled. Aspen does not utilize excessive amounts of water through evapotranspiration processes. Aspen is important both as a watershed protection species (especially in regard to intensive summer rainfall common to the mountain west) and as a vegetative soil type that allows good regimen streamflow (Johnston and Doty 1972).

With all these items in mind, allowing the aspen acreage to shrink or be reduced in vigor by default or ignorance seems to be ill advised, considering the many positive aspects of having a viable aspen forest. As stated previously, the present policy along the Wasatch Front prohibits the cutting of any trees to protect the vital watersheds. With the large, adjacent populations, controlled individual free-use firewood permits could be an effective management tool along the higher populated Wasatch Front area. Well conceived, commercial timber sales may also be a vital management tool.

It is exciting for the land manager to recognize some of the new research information that has been and is now being developed. The Great Basin and vicinity is considered the center of optimum development of aspen in North America and is also an important range cattle producing region (Morgan 1969). The possibility of using aspen bark and other aspen materials as livestock feed offers some potential, without using vital feed grains needed to feed world populations (Baker, Miller, and Satter 1975).

In conifer forest management, one of the real problems at the present time is regeneration of the stands and the exceptionally high costs of planting in poorly stocked, burned, and cutover stands.

Aspen provides an exciting alternative to the land manager because it reproduces vigorously by means of root suckers. These root suckers are produced from sucker buds on the shallow lateral roots, usually from those that are within 3 or 4 inches from the soil surface. Some research indicates that aspen should be cut on a relatively short rotation because sucker reproduction is strongest in the mid-years of its normal lifespan and during a period immediately after cutting, when soil temperatures are held constant and there is abundance of strong light to produce vigorous development of young suckers (Brinkman and Roe 1975).

Changes in both policy and attitude are needed if we want to continue in creative forestry. Aspen's silvicultural characteristics demand it be recognized on its own merits, not the traditional "weed species-noncommercial" attitude of the past. Recognizing the limits placed on the products by economics and public acceptance, planning for the future is important now. Our experience has shown us that "weed species" of a few years ago are a vital part of our economy today. Through recognition of potentials, planning, research, and effective management, aspen can offer the economy and the consumer much in the future.

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Panel II.

Aspen Ecology And Harvesting Responses

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Type Variability And Succession In Rocky Mountain Aspen[1]

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Abstract.--Most of the 6 million acres of aspen lands in the West occur in the Central Rocky Mountains. The ability of western aspen to occupy a wide variety of sites, the great genetic diversity among clones, and the role of aspen as both a dominant successional and stable species severely complicate management. Such ecological and genetic diversity results in considerable variability in both resource production and potential response to management. Progress in classifying the ecological variability of aspen lands is slow; useful partitioning of genetic diversity is nil.

INTRODUCTION

Quaking aspen (*Populus tremuloides* Michx.) occupies a unique position as a dominant forest tree. It is the most widely distributed tree in North America; the aspen type is recognized for its multiple values of wood, livestock forage, wildlife habitat, and esthetics; yet in the West it has received very little management or research attention. Lack of interest in the past probably stems from the weak demand for aspen wood products, which is certain to change with time. Demands for all of the multiple products obtainable from our aspen lands will undoubtedly increase. Already our resource managers are facing the problems created by the broad range of environmental conditions where the type occurs and by the genetic diversity of aspen itself, both of which severely complicate development of reliable management practices.

DISTRIBUTION

Aspen extends across the North American continent from Labrador to Alaska, and as far south as Mexico (Little 1971). It occupies approximately 6 million acres (2.5 million ha) of the western United States. The most extensive stands in the West are found in the Central Rocky Mountains. Colorado and Utah alone contain over 4 million acres (Jones and Markstrom 1973). Although widely distributed elsewhere in the West, in these areas aspen is usually confined to small, isolated stands or rather narrow, transitional zones between conifer forests and grasslands.

Aspen grows under a wide variety of environmental conditions. However, its range in the Rocky Mountains appears to be related to cool, relatively dry summers and winters with abundant snow. Summer temperatures above 90° F (32° C) are rare, while winter temperatures below 0° F (-18° C) are common. Annual precipitation ranges from about 16 inches (40 cm) to over 40 inches (100 cm), mostly in the form of a deep winter snowpack which, upon melting, recharges the soil with moisture sufficient to meet most of the water requirements of aspen during its period of active growth.

Aspen grows at elevations ranging from less than 3,000 feet (923 m) in northerly latitudes to over 10,000 feet (3,077 m) in the more southerly latitudes. In Colorado and Utah, aspen commonly occurs in an elevational belt between about 6,500 feet (2,000 m) and 10,500 feet (3,230 m). Aspen is found on a wide variety of soils ranging from rocky talus slopes to deep, heavy clays. The better stands, however, are usually found on deep, loamy soils.

GENETIC VARIABILITY

Aspen in the Central Rocky Mountains is recognized as a probable climatic race distinct

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[1] Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

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from that extending across Canada and into the Lake States. The Rocky Mountain aspen is designated by the varietal name *Populus tremuloides* var. *aurea*. Great and unclassified variability exists within variety *aurea*, which confuses attempts to develop precise management guides.

Anyone familiar with aspen soon becomes aware of the striking variability in growth form and in coloration of different clones. The almost exclusive vegetative mode of reproduction gives rise to genetically idential trees within a clone (Barnes 1966), which emphasizes the visual impact of phenotypic differences between clones.

Clones of eastern aspen vary markedly in stem form, branching habit, height and diameter growth, leaf morphology, leaf flushing, fall colors, leaf drop, and susceptibility to disease (Barnes 1969; Wall 1971). Similar phenotypic variability apparently exists in western aspen. Barnes (1975) sampled over 1,200 clones from Colorado to British Columbia, and by multivariate analysis of only leaf, bud, and twig characteristics demonstrated variation among 24 basic populations. He found a gradient in leaf characteristics from southern Utah to northern Idaho and Montana. Tew (1970) observed that the nutrient content of aspen foliage differed appreciably among clones of western aspen. For example, clonal differences in protein content ranged from 11.8 to 16.2 percent, suggesting considerable clonal variability in the value of aspen suckers for wildlife browse. It is very likely that growth rates, longevity, and other important but obscure physiological processes also differ markedly among clones. Such clonal variability might well affect the potential of different clones for producing wood products as well as the clone's response to harvesting and other management practices.

Unfortunately, progress in partitioning genetically similar strains within the Rocky Mountain variety of quaking aspen has been minimal.

SERAL VS. STABLE ASPEN

Aspen has generally been regarded as a fire-induced successional species able to dominate a site until replaced by less fire-enduring but more shade-tolerant and environmentally adapted conifers. The extensive stands of aspen throughout the Rocky Mountains are usually attributed to repeated wildfires. This is no doubt true for many of our aspen lands, as evidenced by aspen's relatively rapid replacement (within a single aspen generation) by conifers upon curtailment of fire. In areas of optimum aspen development in western Colorado and central Utah, however, conifer invasion can be so slow that well over 1,000 years of fire-free conditions may be required for aspen stands to progress to a conifer climax.

The uneven-age distribution of aspen trees in some stands suggests that under certain conditions aspen can be self-perpetuating without requiring a major rejuvenating disturbance such as fire or cutting. From a management standpoint, these relatively stable stands of aspen can be considered *de facto* climax. We expect them to remain dominated by aspen in the foreseeable future.

The successional status of aspen on a given area and the ability to recognize seral versus stable stands have considerable management significance. Obviously, we should be wary of planting conifers on stable aspen sites. Also, we must be alert to the need for removing conifers from seral aspen sites if we wish to maintain aspen dominance.

Even though we are reasonably certain that both stable and seral site conditions exist, progress in developing criteria that define environmental conditions indicative of seral and stable aspen communities has been minimal. Harper (personal communication) suggests that the rate of conifer succession might be predicted from knowledge of understory species. For example, on the Wasatch Plateau in Utah, Oregon grape and myrtle pachistima are indicative of areas subject to rapid invasion by conifers, but mountain snowberry and red elderberry indicate a relatively stable aspen community. Harper found that although seral aspen stands appear to be associated with sandstone soils on the Wasatch Plateau, they are associated with basaltic soils on the Aquarius Plateau and with granitic soils in the LaSal Mountains.

As yet, the most valid general indicator of a seral aspen situation appears to be the presence of conifers, which suggests active replacement of the aspen overstory by a more shade-tolerant tree. Mere presence of conifers, however, is not the infallible indicator of a seral condition that one might suppose. Occasional conifers can be found in a basically stable aspen community because of a highly unusual and temporary combination of circumstances favoring conifer establishment. In such cases, a stable aspen community might contain a few scattered, uneven-aged conifers but lack subsequent conifer reproduction. Presence of a multiaged conifer understory is generally reliable evidence of a seral aspen site.

In addition to replacement by conifers, aspen can also be replaced by shrublands or grasslands. Such replacement usually occurs on sites not suited for the establishment and growth of

conifers and where aspen fails to regenerate. Regeneration can fail when apical dominance prevents suckering during gradual deterioration of the clones (Schier 1975). Where suckering does occur in a decadent clone, continued heavy browsing of sprouts by deer, elk, or livestock can prevent successful regeneration and cause conversion to shrublands or grasslands.

TYPE VARIABILITY

The ability of aspen to thrive under a wide range of environmental conditions contributes not only to the confusion in identifying stable and successional stands, but also is reflected in substantial variability in the ability of aspen-dominated sites to produce wildlife habitat, livestock forage, wood, and other needed resources. For example, aspen with a predominant understory of grasses is markedly different wildlife habitat than aspen with an understory dominated by shrubs. Livestock forage production in one range condition class in aspen can vary from 600 to 2,000 pounds of air-dry herbage per acre (672 to 2,242 kilo/ha) because of differences in site potential (Houston 1954). Wood production, measured as annual bole increment, can range from 42 to 194 cubic feet per acre (2.9 to 13.6 m^3/ha) because of site and genetic variability (Jones and Trujillo 1975). Theoretically, we should be able to identify meaningful environmental differences among sites and relate these to quantity and quality of resource production.

Attempts to classify aspen sites, as with most other forest and range types, have relied heavily upon using the vegetation as an integrator of the many factors constituting "environment." Such approaches categorize on the basis of species composition in stable, relatively undisturbed plant communities. Such classification efforts for aspen sites have been few and geographically narrow. The difficulty in developing a site potential classification for aspen is compounded by aspen's questionable status as a stable or seral tree on a given site.

Reed (1971) concluded that a single, stable aspen/snowberry type exists in the Wind River Mountains of Wyoming along with seral aspen communities that are succeeded by Douglas-fir, lodgepole pine, and limber pine at the higher elevations. Severson and Thilenius (1976) found both relatively stable and obviously seral aspen stands in the Black Hills and Bear Lodge Mountains of South Dakota and Wyoming which they classified into nine "aspen groups" according to similarity of vegetation and site. Judging from understory composition, Bunin (1975) determined that four stable aspen associations occupy the west slope of the Park Range in Colorado: (1) aspen/Gambel oak - serviceberry - meadow rue, (2) aspen/sticky laurel, (3) aspen/meadow rue - aster, and (4) aspen/bracken fern - cow parsnip. She also recognized a seral type that is rapidly succeeded by subalpine fir. And, Pfister (1972), while developing a subalpine forest classification for Utah, found apparently stable aspen communities at lower elevations, but concluded that aspen on upper elevation sites is usually a dominant seral species that will eventually progress to spruce-fir climax.

Such studies as these have helped us to understand the ecological variability of aspen communities throughout the Rocky Mountain area. But this understanding is far from complete. We have hardly begun to provide land managers with the guidelines necessary to reliably relate aspen site variability to the potential of these sites to produce important resources, and to determine how these various sites will respond to management. Development of such guidelines must be in two steps. First, we must develop a realistic classification which partitions the spectrum of variability in site capabilities; then we must quantitatively relate resource production and management to these classification units. Once these steps are taken we will be able to offer precise management prescriptions for specific aspen sites.

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Physiological And Environmental Factors Controlling Vegetative Regeneration Of Aspen[1]

George A. Schier[2/]

Abstract.--Formation of suckers on aspen roots is suppressed by auxin transported from the stem. Cutting or injuring the stem decreases the auxin-growth promoter ratio in roots enabling suckering to occur. Carbohydrate reserves supply the energy necessary for bud initiation and shoot outgrowth. Soil temperature is the most important environmental factor controlling suckering.

INTRODUCTION

Aspen (*Populus tremuloides* Michx.) occurs in clones of genetically identical individuals throughout its range (Barnes 1966). The clonal growth habit has resulted because aspen has the ability to regenerate vegetatively by adventitious shoots (suckers, or root sprouts) that originate irregularly on its roots. Under existing climatic conditions in the Rocky Mountains, aspen rarely reproduces from seed (Moss 1938). It has been able to remain a widespread and abundant species only because of its root suckering ability. Fire has played an important role in aspen ecology (Loope and Gruell 1973). Repeated occurrence of fire has enabled clones to increase in size because it resulted in the successive generation of shoots on a continually expanding root system.

Regeneration of aspen will be crucial in any program to manage the species. Because successful regeneration depends on our ability to stimulate sucker production, we should have some knowledge of the physiological and environmental factors controlling sucker formation.

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ORIGIN OF SUCKERS

Suckers arise from the numerous ropelike lateral roots of aspen that occur near the soil surface. They do not originate from preexisting suppressed buds that arise during normal development of primary tissue in the roots as they do in the balsam and black poplars (Schier and Campbell 1976). Instead, they develop from meristems that appear to arise any time during root growth after the formation of the cork cambium. Meristem development probably occurs in response to a stimulus resulting from disturbances in the clone (Schier 1973b). These meristems may develop into buds and then elongate into shoots, but frequently they do not develop beyond the primordial stage. Later, in response to another stimulus, they may develop further. By peeling off the cork, one can usually see very small mounds, preexisting primordia, protruding from the cork cambium.

APICAL DOMINANCE

There is substantial evidence that the development of suckers on aspen roots is suppressed by auxin transported from growing shoot parts, a phenomenon known as apical dominance (Farmer 1962; Eliasson 1971b, 1971c; Schier 1973d, 1975; Steneker 1974). The transport of auxin to roots must be continuous if inhibiting levels of auxin are to be maintained because auxin is rapidly inactivated (Eliasson 1971c, 1972). Interference with the auxin supply by cutting, burning, girdling, or defoliation decreases auxin concentrations in roots. This enables suckers to be initiated or, if their

growth was suppressed by auxin, to continue to grow.

After logging, the number of suckers on aspen roots is proportional to the number of stems removed; the greatest number of suckers arise after a complete clearcut. Not only does removal of all stems reduce apical control to a minimum, but it also enables this shade-intolerant species to grow in full sunlight where it makes its maximum growth.

Sucker formation does not require anything as drastic as logging or fire. This is evident from the occurrence of thousands of shoot primordia and numerous suckers in various stages of development on the roots of relatively undisturbed aspen clones (Schier 1973b). Subtle environmental changes may weaken apical dominance and trigger sucker formation. During normal seasonal tree growth, there may be periods when auxins are at low levels in roots. This is the case in early spring prior to bud burst when temperatures are high enough for the initiation of suckers. This is generally the only time when potted aspen will produce suckers. However, sucker initiation and growth of established suckers is inhibited after buds have flushed out and apical control has reasserted itself.

Apical dominance also plays an important role in limiting regeneration after an aspen clone is cut. Elongating suckers produce auxins (Eliasson 1971a) and translocation of these into the roots may subsequently increase auxin concentrations to levels that inhibit the initiation and development of additional suckers (Schier 1972).

GROWTH PROMOTERS

Adventitious shoot development in aspen roots is probably initiated by cytokinins, hormones that are synthesized in root tips (Peterson 1975; Skene 1975; Williams 1972). High cytokinin-auxin ratios favor shoot initiation while low ratios inhibit it (Winton 1968; Wolter 1968). Obviously then sucker production can be promoted by decreasing the concentrations of auxin or increasing the concentration of cytokinins. Both of these changes do in fact occur in the roots when a stem is cut because auxins can no longer move into them and cytokinins accumulate where they are synthesized. Less success is probably achieved in stimulating sucker production by girdling a stem than by cutting it because, although downward movement of auxin in the phloem is stopped, translocation of cytokinins into the stem via the xylem is not impeded. Consequently, cytokinins do not accumulate in the roots (Farmer 1962; Skene 1975).

Another growth regulator that appears to promote sucker production is a gibberellic acidlike compound (Schier 1973a; Schier and others 1974). It appears to stimulate shoot elongation after suckers have been initiated. Therefore, any interference with its biosynthesis could affect sucker production even if cytokinin concentrations are high.

CARBOHYDRATE RESERVES

After shoot initiation in aspen is triggered by a change in hormone balances, carbohydrate reserves supply the energy necessary for bud initiation and shoot outgrowth. The regions of the root that give rise to shoot primordia actually may be stimulated by heavy accumulations of starch (Thorpe and Murashige 1970). An elongating sucker remains dependent upon root reserves until it emerges at the soil surface and can carry on photosynthesis (Schier and Zasada 1973). The number of suckers arising on aspen roots generally is not limited by the concentration of stored carbohydrates. However, because sucker growth through the soil is sensitive to slight changes in carbohydrate concentration, the density of regeneration is related to the levels of reserves. Low supplies of carbohydrates might be expected to have a greater impact on deep-rooted clones than on shallow-rooted clones because the former would be required to expend a greater amount of energy to put a sucker at the soil surface.

Although aspen has a high capacity to regenerate itself vegetatively, there are limits to how much abuse it can take. Repeated destruction of new suckers by burning, cutting, herbicide spraying, or heavy grazing can exhaust carbohydrate reserves and cause a drastic reduction in sucker production (Baker 1918; Sampson 1919). Defoliation by insects can also cause root reserves to be depleted and to reduce the amount of aspen regeneration produced when a clone is cut.

ENVIRONMENTAL FACTORS

Soil temperature is one of the most important environmental factors affecting suckering by aspen (Maini and Horton 1966; Williams 1972; Zasada and Schier 1973). High soil temperature in exposed grasslands adjacent to aspen clones is thought to be the primary reason for aspen being able to invade these areas (Barley and Wroe 1974; Maini 1960; Williams 1972). The absence of aspen on cooler sites in interior Alaska is probably due to the inhibiting effect of low soil temperature on sucker regeneration (Zasada and Schier 1973).

A great deal has been made of evidence that increased soil temperatures resulting from insolation can cause suckers to arise from roots of uninjured aspen (Maini and Horton 1966). However, it has also been shown that an increase in soil temperature may not always be sufficient to override the effects of apical dominance, although the temperature increase will promote sucker growth after apical dominance is broken (Steneker 1974).

When suckers arise from roots of undisturbed clcnes as a result of high soil temperature, as in aspen invasion of grassland, temperature probably has modified the effects of apical dominance by its effect on cytokinin-auxin balances (Williams 1972). High temperature may lower the effective amount of auxin in the roots by causing its degradation. In contrast, cytokinin production by root meristems is increased (Williams 1972). The resulting high cytokinin-auxin ratio stimulates sucker production.

Light and soil moisture may also play an important role in aspen regeneration. Light is not essential for sucker initiation, but it is necessary for good sucker growth (Farmer 1963). Soil moisture may be critical when there is either too much or too little of it (Maini and Horton 1964). Aspen growing under conditions of severe drought or in soil saturated with moisture produces few suckers.

CLONAL VARIATION

Large clonal differences in the relative capacity of clones to produce suckers have been found when suckers are propagated from root cuttings under controlled environmental conditions (Farmer 1962; Maini 1967; Schier 1973d, 1974; Schier and Zasada 1973; Tew 1970; Zufa 1971). The magnitude of the differences among clones varies with the date of collection (Schier 1973d). The number of suckers produced by a clone is determined by the physiological and anatomical characteristics of the roots at the time of collection. Genotype probably has a large influence on these characteristics, but nongenetic factors such as clone history, stem age, clone age from seed, and site could also be major contributors. Sucker production from roots of different clones often responds differently to chemical treatments (Schier 1973a, 1973c) and to temperature treatments (Maini 1967; Zasada and Schier 1973). There is evidence that the natural variation in sucker initiation, development, and response to treatment may be due to clonal differences in concentration of endogenous growth regulators (Barry 1972; Schier 1973d), carbohydrate reserves (Schier and Johnston 1971; Tew 1970), and to differences in the developmental stages of the shoot primordia (Schier 1973a, 1973c).

The occurrence of clones with an uneven-aged stem structure indicates there are clones in which mortality is quickly replaced by new suckers (Alder 1970). There may be clones in which apical control is so weak or the concentration of growth-promoting factors so high that they sucker vigorously at the least disturbance.

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Diseases Of Western Aspen[1]

Thomas E. Hinds[2]

Abstract.--Decay fungi cause the greatest impact of all diseases affecting aspen's potential for utilization. Trunk cankers kill trees and cause unknown volume losses. Other diseases presently appear to play only a minor role.

Hardwoods, mainly aspen (*Populus tremuloides* Michx.) currently play a minor role in the timber resources of the Rocky Mountains. By the year 2,000, however, the Forest Service projects that hardwood sawtimber removals could be increased from the 1970 level of 13 million board feet to 232 million board feet providing substantial changes occur in hardwood values, plant capacity, and markets (U.S. Forest Service 1973). If these greatly increased volumes of aspen are to be available and utilized in the future, we will need considerably more information on the impact of diseases on aspen management.

Although many diseases attack aspen, relatively few cause loss in living trees. Of these, decay fungi cause the greatest loss in merchantable volume and are responsible for shortening the rotation age. Cankers not only kill the bark and distort the merchantable portions of the trunk, but also cause extensive mortality. The root pathogens not only cause extensive butt rot, but more importantly, predispose trees to windthrow. While leaf diseases may cause some growth loss, they seldom kill trees, and are not usually considered important.

The relative importance of the diseases of aspen found in the West differ from those found in the eastern United States and Canada. This discussion summarizes our present knowledge on some of the important disease problems concerned with management and utilization of aspen in the southern Rocky Mountains.

1/ Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Fort Collins, Colorado, Sept. 8-9, 1976.

2/ Research Plant Pathologist, USDA, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

DECAY

Losses Due to Decay

Baker (1925) was the first to stress the role of decays in aspen management in the West. He presented criterion for site quality, and gave gross cull estimates based on his studies in central Utah. Baker recommended a pathological rotation age of about 110 years on what he had defined as sites 1 and 2, the better aspen sites, to minimize decay losses.

The only quantitative study of aspen decay in the West was by Davidson et al. (1959) in Colorado. In the Colorado study, 53 percent of 976 trees sampled contained decay, which averaged 8.4 percent of the total cubic foot volume. Although there was little relationship between decay and site class for younger stands, the differences were marked in older stands. In 100-year-old stands, cubic foot decay averaged 4 percent on site 1, 8 percent on site 2, and 13 percent on site 3. The incidence of decay was considerably lower than that reported by Meinecke (1929) for aspen in one locality in northern Utah.

The merchantability of aspen on a board-foot basis was recently analyzed[3] by grouping the Colorado data (Davidson et al. 1959) for individual trees (minimum tree d.b.h. 8.0 inches) by 10-year age classes. Cull due to decay plotted as a function of these age classes for Baker's sites 1 and 2 (Baker 1925) showed an essentially linear relationship for the range of the data--40 to 170 years:

3/ Hinds, T. E., and E. M. Wengert. Growth and decay losses in Colorado aspen. Manuscript in preparation, Rocky Mountain Forest and Range Experiment Station.

Tree Age (years)	Percent board foot cull due to decay	
	Site 1 [4/]	Site 2 [5/]
60	6	7
80	13	16
100	21	25
120	28	34
140	36	44
160	44	53

[4/] Site 1 percent cull = -17 +.38 tree age, r = .93

[5/] Site 2 percent cull = -21 + .46 tree age, r = .96

The amount of cull for trees on site 3 averaged 65 percent between 70 and 150 years, but the variation was too large to obtain meaningful relationships.

It appears that sawtimber harvest of aspen on sites 1 and 2 should be optimum when stands are between 90 and 120 years of age. Defect should range between 17 and 34 percent. On poorer sites only marginal utilization of the stands can be expected. In essence, the Colorado and Utah studies dispel the idea that western aspen should be managed on a short rotation period (from about 30 years on poor sites to 50 or 60 years on good sites) similar to the Lake States aspen (Brinkman and Roe 1975).

Types of Decay

Trunk rot was responsible for two thirds of the aspen board foot cull in Colorado[3/]. Decay by Phellinus tremulae (=Fomes igniarius), commonly recognized as the principal cause of trunk rot cull in aspen, was found in 15 percent of the trees and was responsible for a third of the total cull. Many trees with extensive trunk rot have conspicuous conks (fruiting bodies) on the trunk. The estimated board foot cull for an individual tree with 1 to 3 conks at any height, or any number of conks 0 to 16 feet on the bole, is 59 + 3 percent. A tree with conks not in these two classes should be considered a total cull (Hinds 1963).

The second most important trunk rot fungus is Peniophora polygonia. Although its incidence of infection is greater than P. tremulae, it causes much less loss. The fungus does not fruit readily on infected trees, consequently there are no external indications that decay is present. Actual cull attributed to this rot is probably less than that scaled because the incipient stage does not fall out when sawn lengthwise, and is usually considered stained wood.

The remaining trunk rot fungi, with the exception of Libertella sp., cause only minor amounts of decay.

More species of fungi are associated with butt rots than trunk rots. Although butt rots were responsible for only a third of the decay volume in Colorado (Davidson et al. 1959), their true importance is unknown. If the volume losses attributable to windthrow due to root diseases were included (Ross 1976a), their impact would be much greater.

Collybia velutipes causes the greatest amount of butt cull (Davidson et al. 1959). The brown mottle rot often extends above 16 feet in older trees. Ganoderma applanatum (=Fomes applanatus) may be as important as C. velutipes because it not only causes a brown mottle butt rot, but also decays the large roots (Ross 1976b) and is a major cause of windthrow (Landis and Evans 1974). Fruiting bodies of the fungus found at the base of a tree indicate butt cull. They are found in almost all aspen stands. With the exception of Pholiota squarrosa, the other butt rot fungi apparently cause only minor amounts of decay (Ross 1976b).

CANKERS

Trunk cankers are the most obvious disease problem on aspen (Hinds and Krebill 1975). Many fungi infect trunk wounds and kill the living bark tissue, causing annual and perennial cankers. The perennial cankers are the most important for they gradually enlarge until they girdle and kill the tree. Although the slow-growing persistent infections may never girdle, the infected trunk becomes so deformed that it is useless for commercial purposes.

The only study to determine the distribution and abundance of the different aspen cankers in the Rocky Mountains was made in Colorado in 1960. Based on 31 plots (129 sub-plots) in 5 National Forests, canker incidence on live trees was: Cytospora, 4.3 percent; Cenangium, 2.4 percent;

Ceratocystis 4.1 percent; and Hypoxylon, 0.2 percent (Hinds 1964). Nine percent of the trees were dead but still standing. The proportion of the dead trees with cankers was: Cytospora, 54 percent; Cenangium, 51 percent; Ceratocystis, 9 percent; and Hypoxylon, 2 percent. The cankers, with the exception of Hypoxylon, were fairly well distributed throughout the Forests. Several types of trunk wounds were also noted.

Trunk wounds are the infection site for most aspen canker diseases. The relationship of trunk wounds to canker-caused mortality was brought out by Krebill (1972) in his study of aspen mortality on the Gros Ventre elk winter range. Aspen mortality in campgrounds is likewise related to camper-caused trunk wounds. Over 50 percent of the trunk wounds in an extensive campground study were infected, and 98 percent of the tree mortality was attributed to the various canker organisms (Hinds 1976).

The important canker diseases are discussed below.

Cenangium Canker

Sooty-bark canker, caused by *Cenangium singulare*, is one of the major causes of aspen mortality in the West. The fungus was associated with the canker in 1956 (Davidson and Cash 1956), and has since been found from British Columbia southward through the Rocky Mountains into New Mexico and Arizona (Andrews and Eslyn 1960). The fungus infects trunk wounds, penetrates the inner bark and cambium, and spreads rapidly. Cankers can extend to 40 inches in length in 1 year, and reach 12 feet long by 29 inches in width in 4 years (Hinds 1962). Trees of all sizes are killed, usually within 3-10 years. Sapwood stain is common behind the canker, but decay does not usually develop because the dead bark dries out fairly rapidly. A cankered live tree should not be considered a cull, even though the canker is extensive.

Ceratocystis Canker

Black canker is the common name given to this canker (Boyce 1948) described over half a century ago (Long 1918). The canker is characterized as "target-shaped" when young, but is ragged in appearance due to massive callus folds and flaring dead bark which is black when the infection is many years old. While it is probably the most common canker found in western aspen stands, tree mortality is not great (Hinds 1964). *Ceratocystis fimbriata* can attack through the epidermis of leaf blades, petioles, and young stems (Zalasky 1965) but trunk wounds are considered to be the primary courts of infection (Hinds 1972a) and insects the primary vectors (Hinds 1972b). The major impact of Ceratocystis canker is trunk deformity; it is not usually associated with decay.

Hypoxylon Canker

Hypoxylon canker of aspen, caused by *Hypoxylon mammatum*, causes serious mortality only in localized areas in the southern Rockies. (Hinds 1964, Hinds and Jones 1965). It was first observed in the western United States in 1955 (Davidson and Hinds 1956) and has since been observed more frequently on individual trees in the more open aspen stands. While it is estimated that Hypoxylon canker kills 1-2 percent of the aspen volume annually in the Lake States region (Anderson 1964), its overall importance in western commercial stands is unknown.

It does not normally cause trunk rot or tree breakage in the West, where cankers may be 20+ years old before they girdle large aspens. Because the dead cankered tissue and underlying sapwood dry out fairly rapidly, a cankered tree should not be considered a cull.

Cytospora Canker

Cytospora chrysosperma causes bark necrosis, lesions, and cankers on trunks, large limbs, small branches, and twigs. The fungus is a normal inhabitant of the aspen bark microflora, and readily enters and parasitizes bark that has been injured or weakened (Christensen 1940). The disease is most serious on young suppressed trees, and trees that have been stressed by environmental or biological agents (Long 1918). Although *Cytospora* is often found associated with other cankers, it is not considered a primary parasite on healthy trees.

Cryptosphaeria Canker

Cryptosphaeria canker is a relative newcomer to the list of aspen cankers. Although the fungus *Cryptosphaeria populina* was collected on aspen in Colorado in 1897 by E. Bethel, it has only recently been associated with cankers. The elongated trunk cankers, common in many western aspen stands (Hinds 1976, Krebill 1972) are 3-20+ feet long but only 2-6 inches wide. They may spiral around the tree like a snake. Extensive trunk rot is associated with the canker, and trees with large cankers are frequently broken off by the wind. Based on canker symptoms alone, this canker probably has been misidentified as Cytospora canker in the past. The importance of this canker in causing tree mortality and its associated decay remains to be determined.

STAIN AND WETWOOD

Stain (discoloration) is very common in aspen. The discolorations include hues of black, brown, red, yellow, and green. Although decay and canker fungi are frequently associated with various stains, many other microorganisms are involved, some in a successional manner leading to decay (Shigo 1967). Stain normally affects lumber quality rather than quantity; cull deduction is not usually made when the stain is firm and light in color. (U.S. Forest Service 1964).

The amount of stain in western aspen is unknown, but it may be extensive in trees of saw log size. In an Ontario aspen decay study, the proportion of two types of stain increased from about 13 percent of the merchantable volume in stands 41 to 60 Years old to over 24 percent in stands over 120 years old (Basham 1958). The effect of stain on lumber degrade loss needs study.

"Wetwood," a water-soaked condition of wood in living trees, is likewise common in both sapwood and heartwood of aspen (Knutson 1973). Wetwood areas are usually slightly discolored on a cross section of the bole. While wetwood has been associated with wood borers, wounds, and frost cracks in western aspen (Davidson et al. 1959), it also occurs without obvious associations. High populations of bacteria and yeast are found in wetwood, but their role in wetwood formation is uncertain (Knutson 1973).

Lumber drying is perhaps the biggest problem associated with wetwood. The discoloration largely disappears upon drying, but the wood may collapse at the zone between heartwood and sapwood, split and crack, and not meet thickness requirements. Air-seasoning boards containing wetwood prior to kiln-drying reduces collapse losses at mills (Clausen et al. 1949). There are no data on losses attributed to wetwood during the milling process.

MISCELLANEOUS DISEASES

Leaf diseases may have local significance, but their damage is usually confined to reduced growth of severly affected trees. Small trees suffer the most damage, and are sometimes killed by repeated infections. Clonal susceptibility to individual foliage diseases is common, but under optimum conditions whole stands become infected.

The black leaf spot caused by Marssonia populi is probably the most common leaf disease on western aspen. Damage is sometimes widespread covering several hundreds of acres. It has been reported to cause twig and branch mortality, and dieback in the Intermountain Region (Mielke 1957). Annual infection usually repeats only in the lower crown, and the dieback report has not been substantiated.

Ink spot, caused by Ciborinia whetzelii (Baranyay and Hiratsuka 1967) periodically causes considerable early defoliation, particularly on small trees and the lower portion of larger trees.

The "shepherd's crook" disease, manifested by a blackened reflexed shoot with dead leaves, is caused by Venturia tremula (Dance 1959). While larger trees may be relatively unaffected, the current growth of suckers may be severely attacked, resulting in deformed stems. The disease can be severe on regeneration in clear cut areas. Leaf rusts occur sporadically throughout the region, with Melampsora medusa being the most common (Ziller 1965). The alternate hosts needed for the rust's life cycle include several conifers commonly associated with aspen. The primary effect of Melampsora, like Marssonia, is premature leaf drop in the fall. Damage in aspen stands is not considered serious.

Fungi are associated with two types of rough-bark common on the otherwise smooth aspen bark. The fungus Diplodia (Macrophoma) tumefaciens causes woody galls on branches and twigs and gray to black rough bark outgrowths which tend to encircle the bole (Zalasky 1964). Bark infected by Rhytidiella baranyayi tends to be more corky and lighter in appearance, with smaller affected areas frequently angular shaped on larger trees (Funk and Zalasky 1975). Both fungi may persist in the bark many years, but apparently do little harm to the tree.

FUTURE OUTLOOK

Because most aspen stands in the southern Rockies originated following fires within the last 150 years, we cannot expect to see much further expansion of the type. Today it is not unusual to find two age-class stands. Three-age and uneven-aged stands are also to be found. The differences between age classes must be recognized in assessing merchantability of aspen stands.

It is estimated that 29 percent of the commercial aspen forests in the National Forests of the southern Rockies contain sawtimber: trees over 11.0 inches d.b.h. (Green and Setzer 1974). In many of these older stands, decay cull can be expected to run over 20 percent.

Many of these stands are deteriorating and the sites are reverting to conifers. Unless the rate of harvest increases in these older stands, there is the danger of losing untold acres of the aspen type. These older stands on the better sites should be harvested soon so that the site can be retained by aspen and once again made productive.

Half of the commercial areas contain poletimber stands: trees 5.0-10.9 inches d.b.h (Green and Setzer 1974). It is this important size class which should be harvested in the next 2 or 3 decades while the net growth increment is still high. Tree age presently ranges up to 80 years on the better sites.

Although decay will continue to have a long-term impact on the harvest of aspen, the role of canker mortality should not be overlooked. Future studies may show that losses to leaf and root diseases are important under more intensive management.

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Aspen Harvesting And Reproduction[1]

John R. Jones[2]

Abstract.--When aspen stands are clearcut, regeneration by root suckers is usually prompt and abundant and grows rapidly. Partial cutting results in an inferior replacement stand. Dense young stands thin themselves. Artificial thinning is not advised. Many old stands are too decayed to harvest, and constitute a major management problem. Additional overmature stands, uncut, continually move into the cull category.

INTRODUCTION

A major purpose in harvesting aspen is to perpetuate aspen forest for all of its resource values--esthetics, wildlife habitat, and watershed cover as well as for lumber and fiber. Timely and proper harvest is especially important with aspen because aspen does not store well on the stump. Old aspen trees usually become rotten, and old stands may be succeeded by conifers or possibly by sagebrush and bunchgrass (DeByle 1975). Besides harvesting, the other major means of rejuvenating aspen stands, a severe fire, is hard to get when you want it (Fechner and Barrows 1976). And severe fire may be undesirable in many cases, or even unacceptable, for assorted reasons.

To get healthy fully stocked aspen replacement stands that are esthetically pleasing and will produce good crops of timber requires more than just harvesting however. It requires correct harvesting.

Kim Harper and I are writing a book on the ecology and management of western aspen, with help from Norb DeByle and Gene Wengert. It is a detailed reference work. Here I will simply hit some key features of harvesting and reproduction.

1/ Paper presented at the symposium Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

2/ Principal Plant Ecologist, Rocky Mountain Forest and Range Experiment Station. Central Headquarters is maintained at Fort Collins, in cooperation with Colorado State University; author is located at the Station's Research Work Unit at Flagstaff, in cooperation with Northern Arizona University.

SITES

Many aspen stands grow on sites that don't have the potential to produce economic crops of lumber or fiber. They may however produce usable crops of browse, autumn color, or fuelwood. The culture of aspen may be desirable on such sites, and the most economical means may be deficit sales for fuelwood or chips.

But in this talk I will consider only sites that can produce sawtimber at reasonable rotation ages. Decay makes long rotations highly questionable on most sites. A site that takes, say, 130 years to produce codominant trees 10 to 12 inches in diameter is seldom a commercial site for aspen because of decay. It may be someday, but not today or tomorrow.

Aspen stands on some sites may be heavily invaded by Engelmann spruce, subalpine fir, white fir or Douglas-fir in various combinations, or occasionally by other conifers. Where such a site produces good crops of aspen it may still be preferable to favor the coniferous understory in management and grow a coniferous forest on the site. But even very careful harvesting of the aspen will cause some gaps in the coniferous understory, and aspen root suckers will then result in at least a light mixture of aspen, occupying gaps. That is desirable. Should wildfire, wind, or beetles ravage the conifers later, the scattered aspen would reforest the site promptly with root suckers, once again to provide a favorable microsite for reestablishment of the conifers.

From here on I will talk about the harvesting of productive sites where aspen is to be retained as the cover type.

HARVESTING

HOW HEAVILY TO CUT

In general, researchers and experienced aspen managers in the Lake States, Canada, and the West favor or even insist on clearcutting aspen, to get regeneration stands with a minimum of gaps and the best possible growth (Weigle and Frothingham 1911; Sampson 1919; Baker 1925; Zehngraff 1947, 1949; Curtis 1948; Sandberg 1951; Perala 1972; Brinkman and Roe 1975).

On the other hand, Steneker (1972) stated that in central Canada, leaving culls was not detrimental to suckering if the culls "do not form a closed canopy." Larson (1959) reported that cutting only 45 percent of an Arizona stand provided full restocking, with sucker height at age 7 not much less than on an adjacent clearcut. That paper may have influenced thinking on how heavily aspen must be cut to get a good replacement stand in the West. However, the much more complete data in the office report do not agree with the publication. On the study block, in contrast to the operation as a whole, partial cutting had reduced stocking much more than 45 percent--actually to less than 15 ft^2 of basal area per acre. That approaches a clearcutting.

A nearby 50-year-old stand had been high-graded, leaving a basal area of 69 ft^2 per acre. Fifteen years later, whatever suckers may have resulted had disappeared (Martin 1965).

Aspen harvests on the San Juan National Forest have been partial cuts, often heavy. Culls and trees too small for the market were left. They were more or less numerous. Suckering often was heavy, but somewhat irregular. Sucker growth was even more irregular. Growth has been good in the open, for these are good sites. Where residual canopy trees were more numerous, the suckers did not grow well. The result is a stand of irregular structure and growth, distinctly inferior to the parent stands.

These young stands would be better, in many cases much better, if the unmerchantable older trees had been felled at the time of logging or right afterward. The felling of unmerchantable trees on new aspen cutovers has been a standard practice on National Forests in the Lake States for many years (Brinkman and Roe 1975).

As a rule of thumb, I suggest that if the residual unmerchantable stand will be as much as 10 ft^2 of basal area per acre, unmerchantable trees should be felled. That is a judgement figure.

Aspen advance regeneration is likely to be of inferior quality. If there are patches of it in the stand, they usually should be destroyed. They are good places to fell tops or rout skidders through.

Curtis (1948) cited a suggestion from Utah that about 60 percent of the stand volume be taken in a first cut, accelerating growth in the smaller canopy trees, which would be cut about 10 years later when they had grown larger. Something much like that was done in a Minnesota experiment. Variable suckering resulted from the partial cuttings. Sucker growth was inferior to that on an adjacent clearcut. The residual stands were completely removed 6 years later. The suckers resulting from the final cut were suppressed by the poor suckers from the first cut. The replacement stands were the inferior result of the first cut--poor stands on good sites.

A poor stand on a good site is not what we want. We have too many of those already.

SKIDDING

Heavy equipment running all over the place can be bad news. This is particularly obvious on sites where a stand of mixed conifers has been heavily cut and the slash bulldozed. On such areas, even where aspens were numerous in the overstory, suckering is often very patchy--largely absent where traffic was heaviest. There may be very few or no suckers on and around the sites of slash piles or log landings.

Almost all aspen suckers arise from roots within a few inches of the surface (Sandberg 1951). Jammer skidding and heavy tractor traffic tear up a lot of these shallow roots, and poor restocking can result. Skidders can move around freely to hook up with no harm. But once they have their load they should use established trails repeatedly instead of bee-lining for the landing.

This may sound peculiar to some of you who are aware that disking was at one time recommended in the Lake States to stimulate suckering (Zehngraff 1946, 1949; Zillgitt 1951). Stimulation of suckering probably resulted from destruction of competing hazel and mountain maple brush to a large extent. Disking also disrupted the apical dominance of remaining unmerchantable trees.

This too should have helped suckering (Zehngraff 1949). Development of the regenera-

tion stands after disking was not good however, and disking is no longer recommended (Perala 1972, Brinkman and Roe 1975).

THE SUCKER STAND

Aspen sucker stands on a clearcut or burn can look terribly overstocked. Actually, 20 or 30 thousand suckers per acre does not seem excessive at all, and there is no evidence that even 100,000 are too many to start with. Studies in Utah and Arizona (Sampson 1919, Baker 1925, Smith et al. 1972, Jones 1975, Jones and Trujillo 1975) as well as in Michigan (Graham et al. 1963) and Canada (Pollard 1971) indicate that early natural thinning is heavy and effective. The least vigorous suckers die during the first year or two. This first thinning reduces sucker clumps to one or two dominant sprouts. Many other suckers are overtopped soon afterward and die within a few years. Four years after clearcutting on some Arizona plots, about 40 percent of the recognizable suckers had died, leaving about 15,700 survivors per acre. About 40 percent of the survivors were overtopped. As stands continue to develop there is a constant dropping out of canopy trees into the overtopped class, and periodic die-offs of overtopped trees.

Dominants in the sucker stand commonly measure 5-10 feet tall 4 years after clearcutting in the West (Smith et al. 1972; Jones 1967a, 1975; Jones and Trujillo 1975).

During the first few years there are continuous losses of suckers to browsing by deer and elk. In heavily stocked sucker stands these losses are of little consequence, even if they number a few thousand per acre (Smith et al. 1972, Jones 1975). Heavy stands provide an adequate buffer unless sheep use the area the first 3 or 4 years or unless the concentrations of elk or deer are exceptionally high (Sampson 1919, Westell 1956, Packard 1942, Larson 1959, Jones 1967b, Smith et al. 1972). Poorly stocked stands are much more susceptible to being browsed out.

Everything considered, the dense regeneration which normally follows the clearcutting of aspen stands is a plus in providing abundant high-quality forage for big game while providing enough survivors for well-stocked sapling stands. And self thinning avoids stagnation.

None the less, the high density of many aspen regeneration stands has repeatedly spurred interest in thinning. A considerable literature has grown up on precommercial thinning of young aspen (Baker 1925; Zehngraff 1947, 1949; Zasada 1952; Strothmann and Heinselman 1957; Steneker and Jarvis 1966; Sorensen 1968; Schlaegel 1972; Bella 1975). Precommercial thinning has only a minor effect on the diameter growth of dominants, although the growth improvement in codominants is more substantial. Thinning reduces stand volume growth.

Thinned plots in young aspen appear to be growing much better than adjacent unthinned plots, but the appearance is deceiving. The many scrawny overtopped trees on the unthinned plots have a strong visual impact. On the thinned plots one sees only dominants and strong codominants.

Meanwhile thinning increases susceptibility to the poplar borer (Ewan 1960). Sunscald has not been reported from thinned sapling stands. But hypoxylon canker, and in the West other cankers, increase after thinning, because of bark wounding and perhaps in part to increased insect activities (Gruenhagen 1945, Graham and Harrison 1954, Anderson and Anderson 1968, Bagga and Smalley 1969, Hinds 1976).

Having said all this, I will mention a stand in which thinning at age 5 ot 6 is said to have improved volume growth markedly. No particular disease problem resulted. This stand is on the Mancos District of the San Juan National Forest. I hope to measure some plots there shortly.

Compared to precommercial thinning, commercial thinning has the added attraction of partly or entirely paying for itself, and a number of studies have been reported (Bickerstaff 1946, Pike 1953, Heinselman 1954, Martin 1965, Steneker and Jarvis 1966, Schlaegel and Ringold 1971, Hubbard 1972). There have been modest growth increases on the remaining trees. In some cases subsequent veneer production was increased. Trees which would otherwise have been lost were salvaged. Overexposed trunks are subject to sunscald however, and canker infections may increase substantially.

I do not recommend commercial or precommercial thinning. There may be situations where thinning is desirable--where it improves stand values and is safe. If so, we need to define situations and methods before we launch any thinning programs

DECADENT STANDS

Many good aspen sites bear stands that are growing poorly and have litte commercial volume This is because of old age, fire scars, irregular stand structures or other reasons. These stands may be almost completely cull, and in some locales they are the rule.

Yet the sites they occupy have the potential to grow 100-200 cubic feet of usable bole wood per acre per year (Green and Setzer 1974, Jones and Trujillo 1975). Occupied by cull stands they produce no usable wood at all.

These are the real problem stands.

Fortunately, if stocking is not extremely poor, old cull stands have the potential to produce heavy stands of healthy suckers if clearcut or burned (Weigle and Frothingham 1911, Baker 1925, Maini 1968, and personal observation). Uncut, they get worse year by year, and additional stands join their ranks. At the present rate of cutting, cull stands will be a much greater problem in the year 2010 than they are now.

Replacing existing cull stands with young vigorous stands is not a matter of marketing and utilization. It is a matter of purpose, will, and financing. However, harvesting other mature and overmature stands on good sites--stands still merchantable--can reduce recruitment to the cull class. And that is a matter of marketing and utilization.

CONCLUSION

Aspen on good sites is a highly productive forest type, and silviculturally our simplest. It is currently suffering from neglect or poor handling because markets do not support satisfactory silviculture. We have the know-how right now, however, to manage aspen well on good sites when markets allow.

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The Aspen Forest After Harvest[1]

Norbert V. DeByle[2]

Abstract.--Aspen is a unique forest tree with respect to regeneration. It produces abundant root suckers, up to 40,000 per acre are common, after clearcutting or fire removes the parent stand. The rapidly growing sucker stand competes well with other vegetation, but is susceptible to destruction by excessive ungulate browsing. Clearcut areas produce more streamflow and more growth on shrubs and herbaceous vegetation than does the uncut forest. The patchwork of age classes that results from even-age management optimizes wildlife habitat requirements for several desired species.

INTRODUCTION

Quaking aspen (Populus tremuloides Michx.) occupies perhaps the greatest geographic range of any North American forest tree species. Its ability to regenerate prolifically with root suckers that grow rapidly and successfully compete with other vegetation may have played a major role in establishing this large range. Aspen is a pioneer seral species that colonizes denuded areas. In the northern parts of its range, where growing seasons are relatively short, cool, and moist, regeneration will be by seed and by root suckering. Here, in the southern part, regeneration is almost exclusively by root suckering.

Some speculate that the ortets (seedling parents) of Rocky Mountain aspen clones may have germinated 10,000 or more years ago, when the climate here was more conducive to aspen seedling survival. With periodic wildfire to return the sites to an early seral stage, these aspen were favored and the clones expanded through many generations of root suckering into the aspen forests we find today in the West, particularly in the central Rocky Mountains.

In relatively recent years man has had considerable impact on the western aspen habitat: (1) His livestock have overgrazed many ranges, which decimated young suckers, especially if they occurred sporadically as advance regeneration in the understory. (2) He has managed big game (deer, moose, and elk) populations to maintain relatively stable numbers near the carrying capacity of the ranges; again, aspen suckers were browsed back repeatedly on many areas. And, most important, (3) he has prevented wildfire from periodically killing the forest, and thus, favoring extensive aspen sprouting.

As a result of these impacts, aspen on millions of acres will be replaced by conifers or by brush and grass within a century. Through proper management this trend can be halted. Harvesting the aspen, and tending the vigorous sucker stands that develop, has been proven through many years of study and experience in the Lake States and adjacent Canada to be an effective way to perpetuate this seral forest type.

HARVESTING AND POSTHARVEST TREATMENTS

Clearcutting is the only harvesting method that will allow a satisfactory stand of suckers to develop (Baker 1925; Graham and others 1963). Partial cuts result in fewer and less vigorous

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suckers and encourage invasion by more tolerant species. The size of clearcut units will be dictated by economics, environmental constraints, and expected browsing pressure by wild ungulates on the developing stand. Silvicultural constraints are minimal; except for a trivial strip along shaded boundaries, sucker regeneration should be uniformly dense across the entire clearcut area (Jones 1975). If a reasonably well-stocked aspen stand is harvested, in most instances the recommended minimum (Graham and others 1963) of 6,000 suckers per acre should be produced. Clearcutting in Arizona resulted in approximately 14,000 sprouts per acre (Jones 1975). Smith and others (1972) found 30,000 to 50,000 sprouts per acre after clearcutting in Utah.

The manner in which felled trees are limbed, bucked, and transported, and their degree of utilization, will affect associated forest resources and the amount and success of aspen suckering. In a Minnesota study (Zasada 1972), the common practice of limbing and bucking at the stump followed by skidding or carrying the logs to haul roads resulted in the least disturbance to the residual stand, understory, and soil when compared to tree-length or full-tree harvesting systems. Limbing at the stump and skidding tree-length logs was intermediate. Most destruction of the residual stand and understory came from a mechanized full-tree system. Mechanically harvesting full trees leaves virtually no residue in the forest. Zasada reported that destruction of the residual stand and understory brush was necessary for successful growth and survival of suckers under Lake States conditions. This can be accomplished at the time of clearcutting, or by subsequent treatment.

A requirement to cut all stems over 2 inches d.b.h. on the clearcut also goes a long way toward assuring an adequate postharvest sucker stand.

Western conditions are different enough that full-tree mechanized systems and maximum site disturbance may not be most desirable. Slopes are steeper and longer and species composition in the aspen understory is entirely different. Erosion potential from these mountainous lands must be more seriously considered than in Minnesota.

Postlogging treatment may be necessary to assure a fully stocked stand of vigorous aspen suckers. Broadcast burning within a year of harvesting will aid in killing understory brush and residual trees (Graham and others 1963; Horton and Hopkins 1966). However, western aspen sites are difficult to satisfactorily burn--burning conditions may not be acceptable during the first or even second postharvest years. And, if burning is delayed any further the residual parent aspen roots may not re-sucker sufficiently to fully stock the area after the fire (Perala 1974). Fire can be a very useful tool in aspen management, but one that cannot be relied upon.

An alternative to fire is the use of herbicides. Individual unwanted trees may be killed by using a tree injector, or the entire clearcut may be aerially sprayed in late summer (Perala 1971) to kill the residual overstory and brush. Again, spraying must be done within a year or two of harvesting to avoid damage to the suckering capacity of the aspen roots.

ALTERNATIVES TO HARVESTING

It is not necessary to employ the axe, chain saw, or mechanical tree harvester to manage aspen. If the aspen type has sufficient values in the form of wildlife habitat, forage, watershed protection, natural firebreaks, and esthetic qualities to warrant the investment, or if these values plus anticipated future worth in wood products are sufficient, then prescribed fire or herbicides can be used to kill the overstory, retard the brushy understory, and regenerate decadent stands.

A single aerial spraying of 3 pounds per acre of 2,4-D or 2,4-D/2,4,5-T mixture in late summer will accomplish that objective (Perala 1971). The resulting release of a dense brushy understory may require a later re-spraying.

Prescribed burning will effectively kill both the aspen stand and the understory. Excellent regeneration will follow. I recommend it wherever and whenever it can be used. Unfortunately, proper burning conditions are too infrequent in standing western aspen to make this a very reliable technique. The juxtaposition of aspen with much more flammable vegetation types precludes the use of fire as a controllable tool in aspen stands in many mountainous western areas.

TENDING THE GROWING FOREST

Little care is needed once a fully stocked, rapidly growing, even-aged aspen stand has been established. If too dense, the stand will thin itself with little loss in growth due to competition (Perala 1972).

Thinning has been shown to increase production somewhat on saw-log and veneer quality trees (Hubbard 1972; Graham and others 1963), but under western conditions, with questionable economic return.

From the practical standpoint, one can do virtually nothing to prevent or minimize disease and insect damage to the developing forest. Cultural practices, such as thinning, may increase such damage (Perala 1972).

A dense stand of aspen regeneration (40,000 or 50,000 suckers per acre, for example) can withstand considerable browsing. But, this impact must be controlled during the first 10 to 15 years after stand establishment. Aspen suckers are preferred browse by wild ungulates. They can virtually prevent aspen regeneration on winter ranges, and can cause impact on summer ranges, too. Domestic sheep and, to a lesser extent, cattle should be kept out of aspen clearcuts for the first couple years after harvest. Later use should be carefully managed until regeneration is well out of their reach, about 15 feet tall and 2 inches d.b.h.

IMPACTS ON OTHER FOREST RESOURCES

No one value dominates in the aspen type--it truly has multiple values and thus is a multiple use type. A sample of Rocky Mountain forest managers recently placed wildlife habitat as the top value, followed by esthetics and recreation, water, livestock, forage, and wood products in descending order. They felt wood products would become more valuable in the future, but not to the point of dominating management policy. Therefore, the effects of aspen harvesting and management on associated resources must seriously be considered. Only recently have these rescurces been given their due attention in research on aspen management in the West. Thus, there are limited data upon which conclusions can be based.

Water Quantity and Quality

Water yields will increase about 4 to 6 area-inches from aspen clearcuts (Johnston and others 1969; Johnston 1970; Verry 1972). This increased streamflow will diminish as the new stand occupies the site and probably will disappear within 10 to 15 years from sites satisfactorily regenerated with aspen. The increment to streamflow will occur as base flow and interflow. It comes from more water being retained in the soil mantle at the end of each growing season during the years following cutting, before the upper 6 to 12 feet of soil again become occupied by aspen roots.

There is very little overland flow in an undisturbed aspen forest. Properly done, clearcutting should not increase overland flow appreciably. On sloping lands, at least 65 percent cover of some kind needs to be maintained (Marston 1952). Serious soil erosion will occur from overland flow if cover is depleted below this level. Some overland flow can be expected from roads and, to a lesser extent, from skid trails. These flows usually can be infiltrated into the forest floor before they reach the stream if the road and skid trail network is correctly designed, located, and properly treated.

Water quality may be slightly altered. Increased flow and the possibility of overland flow from the disturbed area have the potential for increasing stream sediment load. However, if properly conducted, clearcutting should produce very little sediment, and that for only a year or two before the site becomes fully revegetated.

Nutrient cycling is temporarily halted by clearcutting--which may produce an increase in dissolved ions in streamflow. Typically, this will occur as a surge during the first 2 years after harvesting. Prescribed fire is likely to increase the magnitude of this nutrient flush (DeByle, in press). These predicted water quality changes in part are extrapolated from other forest types. Aspen clearcutting, in at least one instance, resulted in no detectable changes in stream-water quality (Verry 1972).

Soil

Except for possible depletion of some plant nutrients with short rotations or with whole-tree utilization over many cutting cycles (Stone 1973; Boyle and others 1973) the soil should not be significantly affected in the long term from careful aspen harvesting. Temporary changes to be expected are decreased amounts of organic matter and total nitrogen and altered contents of available nutrients. These changes are due to increased radiation reaching the forest floor, an altered soil microclimate, less organic debris added annually, and an interrupted nutrient cycle (DeByle 1976). Rapid regeneration of aspen will quickly dampen these effects on good sites (Boyle and others 1973).

If carefully done, aspen clearcutting should not disturb the mineral soil sufficiently to cause significant erosion. Generally, aspen sites revegetate readily; any bared soil again should be protected within a year or two. However, pocket gophers can consume some of the protective mantle of herbaceous vegetation and expose soil to erosion on Rocky Mountain aspen sites (Ellison 1946; Marston and Julander 1961).

Wildlife

Wildlife populations will be affected by aspen harvesting. From man's point of view, most of the effects are favorable. Providing even-aged patches of aspen representing all age classes will benefit deer, moose, elk, and grouse. Browse for ungulates is present in abundance during the early years (Graham and others 1963; Byelich and others 1972) and grouse habitat is best if all aspen age classes are present in close proximity (Gullion and Svoboda 1972). Aspen browse and leaves are often the most abundant components of deer diets (McCaffery and others 1974; Julander 1952). Clearcut harvesting of eastern hardwoods and the resulting even-aged regeneration provide nesting habitat for a greater diversity of bird species than no cutting (Conner and Adkisson 1975). Beaver almost exclusively use aspen and other closely related species for food and dam building (Bailey 1922). In short, merely keeping a diversity of habitats and maximum of edge through maintaining and managing the aspen type will benefit many wildlife species.

Forage and Understory Production

The production of forage as well as the composition and production of all understory plants will be influenced by aspen harvest. There is a paucity of data from the West in this regard. Ellison and Houston (1958) found increased production of selected species in openings and on trenched plots under aspen as compared to plots under undisturbed aspen forest. More recently, research being conducted by the Intermountain Forest and Range Experiment Station indicates what will happen to production during the first year after clearcutting or after burning.

A year after aspen clearcutting in northern Utah approximately 1,850 pounds per acre was produced as current year's growth on shrubs, forbs, grasses, and annuals on cut plots as compared to roughly 1,600 pounds per acre under the undisturbed aspen canopy. A year of precut sampling showed about 100 pounds per acre less production on the plots to be clearcut than on the controls. Thus, there is indication of an increase of 300 to 400 pounds per acre following cutting.

Because of damge to the understory, burning an aspen stand in northwest Wyoming in 1974 produced the opposite results. Production of grasses, forbs, and especially shrubs was markedly decreased. Prior to burning in 1974 there was 1,550 pounds per acre production on the control plots as compared to 1,265 pounds on the plots to be burned, a difference of 18 percent. In 1975 there was 2,012 pounds per acre production on the controls and only 925 pounds on the burned area, a difference of 54 percent.

In both instances, these are only first-year results. The temporary setback in understory production after burning could be negated by high production in succeeding years. The understory reduction from fire favors aspen sucker production during the first few postburn years.

Esthetics

Esthetics will be improved in the long run, but perhaps adversely affected in the short run, by managing and harvesting aspen. Harvesting requires roads for access. To minimize several adverse impacts (erosion, stream sedimentation, visual impact, and unwanted and uncontrolled public access), these roads should be minimal in number and closed and "put to bed" when not needed.

Clearcutting causes adverse visual impact in any forest type. Fortunately in aspen, because of the lush, rapid-growing understory, this impact is minimal and short-lived. Keeping the clearcut patches small and irregular in shape will reduce the visual esthetic impact.

Harvesting, and thus maintaining aspen as a forest type in juxtaposition with conifer forests, brushlands, and grasslands will maintain and improve the amenity of the western mountain landscape. The alternative is to erase much of the aspen from these landscapes within a century through succession to conifers or brushlands.

SUMMARY

On most sites aspen is a seral species, dominating the community for a span of 50 to 200 years or more. Harvesting the aspen forest by clearcutting on approximately 80- or 90-year cycles will set back the successional process and maintain the aspen type on sites where it is desired. The alternatives to clearcut harvesting (fire or herbicides) will accomplish the same objective, but do not utilize the wood. For economic reasons, it is doubtful that much aspen acreage will be managed without wood utilization.

The ideal aspen clearcut several years after harvesting will have about 12,000 vigorously growing sprouts per acre. For the following decade or more it will provide an abundance of browse for big game, will yield a third of a foot more water than the mature aspen

stand, and will be visually acceptable or even pleasing as part of the landscape. During the first year or two after harvest the quality of streamflow may be slightly lowered with dissolved nutrients and sediment. The soil and site are disturbed by the harvesting process, but they rapidly return to preharvest conditions as the aspen suckers again develop a closed forest canopy.

Within 2 decades after harvesting a good site will have essentially returned to the conditions found in a mature aspen stand. Breeding grouse habitat is ideal in these pole-sized stands, increment of wood is now at its peak, and the forest appears most vigorous.

From about 30 years to the end of the cutting cycle at 80 or 90 years, the aspen forest continues to grow and to naturally thin itself to some 300 to 600 stems per acre. Shade-tolerant tree species, such as spruce and fir, begin to invade the stand. It is essentially a mature aspen forest with respect to all resources except wood production. When it matures for production of wood, the stand is clearcut and the cycle begins anew.

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Response Of Aspen To Various Harvest Techniques[1]

Howard R. Hittenrauch[2]

Abstract.--Aspen is an important component of both the Engelmann spruce/subalpine-fir and the Douglas-fir/white fir types. On all recent San Juan National Forest sales, aspen has been part of the included timber. Harvesting responses differ for three situations - aspen is a mature part of a coniferous overstory; aspen is an overstory with a fully stocked coniferous understory; aspen is a pure stand with no coniferous mixture. Effects of grazing, residue volume, and cutting intensity are considered.

Commercial aspen type occurs on 269,000 acres or 21% of the commercial forest land on the San Juan National Forest. Within the aspen type, approximately 20% of the cubic foot volume of the stands is associated softwoods. Of the 269M acres of aspen type, 66.5M acres are classed as sawtimber, 119M acres are classed as poletimber and 85.5M acres are seedling-sapling or non-stocked.

Analysis of the stand age data indicates that many of the stands reach rotation age without growing to sawtimber size. Hinds has recommended a rotation of 80 to 100 years in the Rocky Mountains. There are 89.5M acres over 100 years old. For this to happen, at least 23M acres of pole timber must be over rotation age.

Aspen also occurs as a component in the conifer types. Within the spruce-fir sawtimber type, aspen represents 5% of the cubic foot volume, or 3% of the board foot volume of the stands. In the Douglas-fir--white fir sawtimber stands, aspen represents 11% of the cubic foot volume or 7% of the board foot volumes of the stands. Aspen is almost totally absent from the ponderosa pine type, representing less than 1% of the cubic foot volume of these stands.

1/ Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

2/ Forest Silviculturist, San Juan National Forest, Durango, Colorado

During the previous 10 years, the San Juan has harvested an average of 4.1 MBF per year of aspen sawtimber. There are only minor markets for products other than sawlogs. The cut of aspen sawlogs has not been a major part of the Forest harvest, representing only 5½% of the total sawlog harvest. While aspen is not a major part of our harvest, we have not entirely ignored the silvicultural management of the type.

On all of the recent timber sales on the San Juan, aspen has been a part of the included timber. Falling and removing of designated aspen is required on these sales. The more recent timber sales in the spruce-fir type, and the Douglas-fir--White-fir type, have generally received an intermediate cut or a first-stage shelterwood cut. These sales have been individual tree marked. No attempt has been made to eliminate aspen as a component of these stands. When mature aspen trees are encountered, they are marked for removal. Because of differences in rotation age between aspen and conifers, and because the aspen is often residual trees on sites that have converted to conifers, the harvest of aspen from these stands is frequently greater than the part of the stand in aspen. Conifer sales containing 10-15% aspen volume are not uncommon.

Aspen has responded well to this treatment. There are sufficient overstory conifers to maintain the conifer type. Small openings have regenerated to aspen. Thus aspen will continue to be an important component of these stands.

Aspen occurs as an almost pure overstory in stands with full stocking of conifer understory. We have made overwood removal cuts in these stands, removing all aspen over 8" DBH

(fig.1). The response has been favorable. The conifers have increased both in diameter and height growth. Due to irregularities in stocking or to logging damage, the conifer reproduction seldom fully occupies the site. Where openings occur, aspen reproduction has been quite abundant (6,000-10,000 trees per acre). Aspen will continue to be a strong component of these stands but the future stand will probably be typed as a conifer stand.

Figure 1.--Aspen overwood removal two years after harvest.

Aspen also occurs in essentially pure aspen type. There have been a variety of harvest techniques in these stands. In the mid 1960's, a sale was let where only the merchantable trees were felled and removed. Later sales in the late 1960's required all trees over a given diameter (either 8" or 10") to be felled and removed. The response to this type of harvest is directly related to the amount of residual stand left after harvest. The most recent sales in this type have required that all aspen trees over 2" DBH be felled. Falling unmerchantable trees can either be the purchaser's responsibility, under the terms of the timber sale contract, or can be done by the Forest Service with deposited KV funds.

A series of aspen cuts made in 1965 and 1966 is worthy of mention. These stands were decadent at the time of harvest. Only merchantable trees were felled. This resulted in a residual stand of decadent trees and very light slash on the ground. The area has had unrestricted cattle use since harvest. Today, these areas have essentially converted to grass. Because of the partial cut, aspen reproduction was weak. Data are not available, but reproduction was probably about 1,000 trees per acre. The overstory undoubtedly suppressed the height growth of these trees. Cattle browsing and trampling damaged what reproduction did occur. Today there are no reproduction trees which can be considered as potential crop trees. This system of management is not recommended if the intent is to produce crops of aspen. However, it appears to have merit if the intention is to reduce the area of aspen and increase the area of rangeland.

Other areas cut to a minimum diameter limit, usually 10" DBH, have responded well and are now overstocked with potential crop trees. These stands were not decadent at the time of harvest. Generally, there were sufficient trees of merchantable size that a relatively light residual stand was left. Regeneration occurred and height growth has not been retarded. Residual basal area appears to have been in the range of 30 to 60 square feet per acre. Some of these stands have now been recut to remove the residual trees from the original harvest. This recut is only one or two years old but it appears that the damage to the 10-15 years old reproduction is within acceptable limits. New sprouting is occurring in openings in these stands.

Some, but not all, of the areas cut in the 1960's have received moderately heavy grazing use. The trees in these areas appear sound and well formed. Browsing was not heavy enough in these stands to restrict height growth. The trees are now 10 feet or taller and above any browsing damage. However, many of these trees show signs of basal scars, probably caused by trampling. Most of these basal scarred trees have a discoloration of the heartwood. The pathology lab has identified this as an unknown stain causing fungus. Whether or not this fungus will prevent the trees from producing usable sawlogs remains to be determined.

The most recent sales in pure aspen type have been true clearcuts. All aspen trees 2" DBH and larger have been felled. The response to this treatment has been impressive. Sprouting has occurred at the rate of 6,000 - 10,000 stems per acre. In the second growing season, dominant trees are 6 feet tall (fig.2). There is only minor sign of wildlife browsing and no cattle damage. None of the trees yet show any sign of the unidentified stain-causing fungus. Because all of the trees were felled, the areas are more pleasing visually (fig. 3); the ragged appearance following commercial clearcutting is absent. The unmerchantable debris on the ground has created a barrier which discourages cattle use (fig. 4). Although this debris is now serving a useful purpose of discouraging animals use, it remains to be seen if this debris will also discourage future silvicultural activities in the stand.

Figure 2.--Aspen clearcut second growing season after harvest.

Figure 3.--Aspen clearcut second growing season after harvest.

Figure 4.--Aspen clearcut two weeks after harvest.

Harvesting and obtaining regeneration is not an end in itself. Once regeneration is established, the new stand must be properly tended. Various research studies, along with local observations, show that unrestricted browsing and trampling can destroy a new sprout stand. Therefore, some measure must be taken to restrict this usage. In most cases, complete protection is not practical and probably is not necessary. The key seems to be restricted use, either by range management practices or by leaving sufficient debris so as to discourage animals from using the area.

There is a wide spectrum of opinion regarding the desirability of precommercial thinning in aspen stands. Research papers can be found which support both sides of the question. I consider that pre-commercial thinning is desirable on the San Juan. Our management is based on sawtimber production. Many wild stands have reached rotation age while still in the poletimber size class.

The foregoing is based on several years' observation of aspen response on the San Juan. Unfortunately, exact numerical data are not available.

Table 1.--Area of commercial forest land on the San Juan National Forest

Type	Acres
Spruce-fir	421,021
Ponderosa pine	342,548
Douglas-fir-white fir	231,529
Aspen	268,864

Table 2.--Area of aspen by stand size class

SSC	Acres
Sawtimber	66,505
Pole timber	118,703
Seedling-Sapling	23,634
Non-stocked	60,022

Table 3.--Area of aspen by age class

Age Class	Acres
0-20	60,022
21-40	14,209
41-60	67,844
61-80	33,624
81-100	3,623
101-120	25,498
121+	64,044

Table 4.--Cubic-foot volume of aspen in sawtimber stands, by timber type

Type	MCF
Spruce-fir	64,470
Ponderosa pine	1,888
Douglas-fir--white fir	43,933
Aspen	108,301
	218,592

Table 5.--Board foot (Scribner) volume of aspen in sawtimber stands, by timber type

Type	MBF
Spruce-fir	226,514
Ponderosa	-0-
Douglas-fir--white fir	111,479
Aspen	337,600
	675,593

Table 6.--Board foot (Scribner) volume per acre of aspen in sawtimber stands, by timber type

Type	BF/A.
Spruce-fir	590
Ponderosa pine	-0-
Douglas-fir--white fir	570
Aspen	5076

Table 7.--Board foot (Scribner) volume of aspen and percent of total cut in the past decade

CY. Year	MBF Cut	% of Forest Harvest
1966	6,692	7.5
1967	3,440	3.7
1968	2,489	2.4
1969	4,219	5.5
1970	3,913	5.5
1971	3,452	4.8
1972	3,874	5.5
1973	5,371	7.8
1974	4,591	8.2
1975	3,372	8.1

Ten Year Average: 4,141

Panel III.

Market Opportunities And Limitations For Rocky Mountain Aspen

Moderator: Garrett Blackwell

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Lumber Markets For Rocky Mountain Aspen[1]

Gordon K. Runyon[2]

SUMMARY

At present, Rocky Mountain aspen is just being sold, not marketed. In only one case, "Great Scot" paneling, has there been any real market planning. The marketing plan should assure that when trees are logged, the operator knows where the wood is going.

For the past decade, Rocky Mountain Aspen has been marketed primarily as box and crating lumber. Even though aspen has been recently marketed as shakes, paneling, decking, and studs; it has not generally been accepted as a substitute for the species now being used in these products. Several mills are now experimenting with new products, including new paneling designs, shakes, tongue and groove decking, and studs.

The biggest problem in processing and marketing aspen lumber products is the poor quality of drying that can be, or is being achieved by the mills at present. A second barrier is not being able to provide a consistent supply of aspen products. Another is failure to take advantage of already established markets in the eastern U.S.

1/ Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, September 8-9, 1976.

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Aspen Market Opportunities: Lumber, Excelsior, And Residue[1]

Mark S. Koepke[2]

ABSTRACT,--Rocky Mountain aspen is presently being marketed for lumber, excelsior and residue products. These include pallet stock, paneling, sawn mine material, excelsior, match sticks, novelty items, firewood and sawdust. This paper discusses these plus industries that didn't make it and future markets.

Aspen is truely an untapped resource in the Rocky Mountains. However, in order to utilize a resource, markets must be developed and profit obtained. The inability to find these markets has been one of the major hinderances to the utilization and proper management of aspen in the Rocky Mountain States. Aspen is used heavily in the Lake States for numerous products, so it can be a viable source of wood fiber. The question is, how can it be made economically viable in the Rockies?

Information within this paper was gathered through contacts in both industry and government. The mention of company names is not intended to promote that particular company or its products, but provide examples. In the same way, if certain companies producing aspen products are omitted, please understand no offense was intended. Also, in the Beehive State of Utah, sometimes those rascals deposit a waxy substance in your ears. Therefore, take the information, especially prices, with this in mind.

It seems logical, in order to sell a product, you ought to know what you're selling. Aspen traditionally has had a poor name, because it has not been properly sold in regard to its unique characteristics. For instance, a piano company tried to use aspen for a part demanding numerous screw holes. It was applied without knowledge of its inferior nail-holding ability. Thus, by not using more, and possibly larger screws, aspen failed. Although characteristics may be covered in other papers, let's take a look at aspen from a marketing standpoint.

Aspen is a fine-grained, light, soft hardwood. The color is white to light brown. It is odorless when dry, tasteless, non-resinous, and resistant to splitting (especially end-splitting when nailed). The wood is fairly dimensionally stable after drying. Gluing qualities are excellent, according to The Wood Handbook. Aspen also has good printability. Its strength can be compared with basswood, with the wood excelling in toughness.

Aspen also has its problems. The trees themselves cause milling problems because of recurrent crook and sweep. Aspen is also susceptible to much disease, causing stain, heart rot and bole misformation. Wengert (9) says an average log yields 15% bark, 45% sawdust and residue and 40% lumber (15% upper-grades, 85% lower). It will be necessary to find stable markets for lower grades and residue, to keep operations profitable.

Other problems with aspen include drying. Wetwood in aspen drys very slowly, making air drying almost a necessity, before kiln drying. Poor drying techniques are accentuated in aspen by showing large amounts of drying degrade. Nail-holding qualities are poor, however, larger or different nail designs improve this markedly. The wood also deteriorates quickly. Aspen machines easily. It will tear and fuzz, though, when proper turning speed and sharp knives at the correct angle are not maintained. These are not all of aspen's characteristics, but keeping these few in mind, marketing aspen is the next step.

1/ Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, September 8-9, 1976.

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ASPEN LUMBER

Preliminary data concerning the volumes of aspen harvested in Rocky Mountain States during 1974 have been computed. In Utah, Colorado, New Mexico and Arizona aspen sawlogs ranked first in volumes cut. The majority of the lumber produced from these sawlogs went into pallets, paneling and mine materials. Hardly any Rocky Mountain aspen is used in construction lumber. Presently, aspen lumber products provide a wide market potential and, generally, the highest return, when compared to other aspen uses.

About 12.7% of the lumber produced in the U. S. during 1975 goes into pallets. By 1985, 400 million pallets will be needed (2). Aspen pallets use much of the aspen now harvested in the Rockies. Dr. Walter B. Wallin, at the Forest Products Marketing Laboratory in Princeton, West Virginia in cooperation with Dr. E. George Stern at VPI, have been studying aspen pallets for some time. Dr. Stern has written three excellent publications on design and strengths of aspen pallets (5,6,7). In August of 1975, Dr. Wallin (8) wrote me a letter saying:

> "To date, aspen has not been widely accepted for permanent pallets for several reasons:
>
> 1. To obtain a pallet which will provide equivalent performance to an oak pallet (60 percent of our hardwoods in the East are oaks) requires stringers 3 inches wide in aspen in lieu of 1-3/4 inches in oak.
> 2. To provide equal-strength joints, the nails used in aspen should be 3" by 0.120"; and there should be six nails per 6-inch deckboard joint and four nails per 4-inch joint. In oak, 2-1/4" by 0.110" size with three per 6-inch and two per 4-inch joint.
> 3. The cost differential between aspen lumber and oak lumber has not been sufficient to justify the increased footage and increased nailing.
> 4. In the East, pallet producers and pallet users have become accustomed to processing and using the 1-3/4 inch stock, and they are reluctant to make the changes in their processing.
> 5. In the past, attempts to use aspen, pine, fir and other softer species have been made with no compensation in size or fastenings when the softer species were used. As a result, the performance was bad; and most users will not accept soft species readily, if at all.
>
> I am convinced that pallets can be produced from aspen or cottonwood which will perform as well as the oak pallets...".

One pallet company in Denver that uses quite a bit of aspen is Denver Reel and Pallet Company. Quoting another letter, Mr. Karl Heimbrock (3), President of Denver Reel and Pallet Company, writes:

> "Our purchases are random length, approximately 80% 1x6 and 20% 1x4, green S2S to 7/8" in a 4 & BTR grade. Aspen is used only for deckboards, lead and otherwise. Our 2x4's or stringers are mixed white woods due to their superior nail-holding capabilities. Aspen is used primarily in the manufacture of permanent warehouse type pallets but is also used in expendable or one-way pallets where greater strength is required. We are purchasing aspen wherever it is available...".

Therefore, aspen, used for pallets, has an excellent market potential, if it is used properly. Two things to note in Mr. Heimbrock's letter, 1) grades down to a #4 can be utilized, and 2) no special nailing procedure is necessary, if the aspen is used only for deckboards.

Solid paneling is another product produced from aspen lumber. The largest producer is Great Scot Timber and Logging

Company, Englewood, Colorado. Great Scot, who's mill is in Bayfield, Colorado, makes a tongue-and-grooved, about 1/2" board; four or six inches wide, in random lengths up to eight feet. They purchase green 6/4 and 5/4, #1, #2 and #3 commons, then dry it to 7% in their kiln. High grades of boards are too plain, and lower grades may have loose knots or larger defects. No wane or rot is allowable in paneling. Great Scot buys their lumber on the open market, but have not been completely satisfied with quality control or availability of Rocky Mountain aspen. In fact, on some occassions, they have purchased Lake State's aspen. They hope to utilize 5MMbf of aspen this year.

After drying, resawing, planing, shaping, cutting-off and possibly, staining takes place. One side is planed; the other is left rough, for a tweedy look. In Utah, the paneling runs between $.55 and $.70 a square foot for natural, and may go as high as $.80/ft^2 for stained. Markets for aspen paneling are nationwide.

Another use of the paneling is in the sauna bath business. Aspen is used in place of redwood because, 1) no splinters, 2) no staining with sweat, 3) very small dimensional changes in the changing environments, and, 4) it's cheaper. The sauna bath is completely lined with aspen, then controls, and possibly redwood floors and benches are added. A sawmill in Utah sends all their green, rough 8', 8/4 selects and clears to California for this product. Great Scot paneling is also sometimes used. Retail prices run about $.90 a square foot for sauna paneling. Paneling out of aspen appears to be a very viable market, but provides limited use of the total aspen tree, because of the grades needed.

Mine cribbing, caps, wedges, and washers are also made from aspen lumber. Cribbing is squared 4x4's and larger, about 30 inches long. They can be as large as 12x12". In long-wall coal mining, these blocks of wood are built into a square shape from floor to ceiling, in order to keep ventilation and access shafts open. Wedges are tapered boards of various widths and lengths. They are used to tighten fits on the tops and bottoms of cribs and between props and caps. Caps are short blocks of 4x4's used on top of props, to butt up against the roof or floor. Washers, also called "holy boards", are 2x8's, 2x10's and 2x12's, with a hole drilled in the center. These are used with a continuous miner (digging a tunnel). The washers work in conjunction with roof bolts to support the ceiling.

Kilborn (4), in an unpublished USFS paper, says an average of 1.25 board feet of sawed material is needed for each ton of coal produced in Utah. By 1985, just Utah should be mining 36 million tons of coal needing 45 million board feet of sawed material. Aspen can be utilized for mine material. Market prices run about $.80 for a 4x6x30" crib ($160/Mbf) about $.25 for a 2x6x18" wedge ($167/Mbf), and, between $.35-$.45 for a 2x8x18" washer ($200/Mbf). The possibilities of this market for aspen is tremendous. It is an especially good market because mines accept green material, with discoloration, some punk and fairly large knots. Cribbing particularly helps to utilize low grade centers of aspen trees.

Residue produced from aspen lumber is not utilized to any great extent. One mill in Utah tries to sell the sawdust for animal bedding (clean, odorless, splinterless and very absorbent), and the slabs for firewood. Most mills, however, still burn it or, where that is illegal, pile it. Mills in New Mexico and Colorado may have a use for it, I don't know.

EXCELSIOR MARKETS

In the 1974 Rocky Mountain harvesting data, aspen cut for excelsior was almost equal to that cut for lumber in the States of Utah, Colorado, New Mexico and Arizona. Excelsior is used in cooler pads, packaging and cover mats for reseeding along road cuts. By far the largest purchaser of aspen for excelsior in the Rockies is AMXCO (American Excelsior) headquartered in Arlington, Texas. They own a total of five mills - two in Wisconsin, one in California, one in Cedar City, Utah and one in Englewood, Colorado. There are also two or three independant mills in Colorado.

AMXCO contracts out all their cutting. The mill in Cedar City accepts tree length

logs, and 100-inch peeled and unpeeled bolts. The company pays $36/cord for peeled sticks, and $25/cord for unpeeled. The wood is dried nine months to a year before being cut into 18" blocks. Excelsior machines can handle diameters up to 20" and down to 6". Clear, unstained aspen is most desirable, however, some defect can be tolerated. Residues of bark, sawdust and small slabs of wood are produced during the manufacturing process. In Cedar City, the bark and sawdust is hauled to the dump, and the wood is given away for firewood. Although excelsior markets fluxuate constantly, excelsior will provide a continued use of Rocky Mountain Aspen.

MATCH STICKS

The Ohio Match Company has a match stick plant in Mancos, Colorado. They harvest 1-2 million board feet of aspen per year; but are unable to utilize all of it. The problem stems from the fact that they are unable to accept any rot, discoloration and diameters smaller than 8". This is because of stringent strength tests required of the matches, plus, the problem of lathe size requirements and spin-out. Ideal bolt size is 14-16 inches in diameter. The plant produces about 25 million splits (or match sticks) /day. Match splits will continue to provide a market for aspen, but does not appear to show any potential for future growth.

Residue in match split production is produced from rejected logs, bark, veneer cores and split rejects. Presently, Ohio Match's low quality logs are shipped to an excelsior mill. Some veneer cores are utilized for excelsior, however, most cores are sent to California for furniture legs. Some cores also end up on plastic longhorn horns produced by a Texas firm, and some goes for firewood. All other residue is burned to fire the boilers.

NOVELTY ITEM MARKET

Recently, as many as six new firms have been established in marketing aspen tourist type items. All of these companies seem to be in Colorado. Most utilize standing dead material (sooty bark) and/or sick green (*Fomes ignarius*) to obtain the interesting colors and designs in the wood. Items are turned, sawed and left in the round. They include things like mushrooms, candleholders, and little forest scenes set in cross sections. A few companies are also expanding into bed posts, vases and lamp stands. Presently, volumes utilized are quite small and come off of Forest Service and private lands. A company in Rollinsville, Colorado, makes jewelry items with aspen leaves that have been dipped in gold or silver. Another, in Loveland, shoots dye into young saplings, then uses the colored wood for jewelry. Mr. Bob Dyans (1), of Aspen Wood Products, Evergreen. Colorado says that aspen sells for emotional reasons. He feels people like to hear that only dead trees are cut (ecology), that every piece is hand-crafted, and that people can relate aspen to a good experience they had in the Rockies. He has a good point, and this use of aspen has potential, especially using low grade trees.

PRODUCTS THAT DIDN'T MAKE IT

Mink Bedding

In the Rocky Mountain region, mink bedding is a relatively new product being produced from aspen. Utah has the second mill in the country which specifically makes this bedding. The other one is in Wisconsin. The product is a fiberous, shredded material that is sold by the sixty-five pound bale for between $2.35 - $3.00. The bedding is used by mink farmers to clean the pelts a few months before killing, and to provide nesting material for the kits. Aspen is the preferred species because it is non-resinous (for clean pelts), and it is splinterless (small splinters get in the kits eyes and blind them).

Aspen bolts 7'9" long are needed for Utah's mink bedding operation. Originally, it was thought that the production of bedding would help use small diameter, crooked stemmed aspen however, the operator found straight bolts, about 10" in diameter, were the most efficient. Production machinery consists of a shredder, dryer, bulk storage facilities and baler. The shredder is a large box moving hydraulically across

spinning, toothed rollers. There is no residue left from the bolts, though a fine dust is blown off during drying. Markets for the bedding included all the western states. Also, because the facility was capable of producing more bedding than demanded, the pet bedding market was explored. This potential market looks very good, unfortunately, the operator went out of business before it could be tried.

Marketing the fine dust residue, produced at the dryer, was another problem. A company which sells mud for oil well drilling bought some for $.12 a cubic foot. The operator felt this was a rather poor return. Other markets were mulch material (mix with mink droppings and let set for a year - market value $30-50/cu. ft.), hydromulch (worked fine, except needed tracing color - market value $122/ton), and wood flour as a glue extender (samples were sent for analysis). Once again, bankruptcy halted further investigations.

The mink bedding operator went out of business for a number of reasons. Of primary importance was the harvesting of the aspen. There were many hidden costs, such as tires, road grade (even on established roads), aspen's variability, saw breakdowns, etc., of which he was not aware. Also, because he was only the second of a kind, capitol expenditures and machinery inefficiencies and breakdowns at the mill were excessive. The Utah Mink Growers Co-op has taken over the mill and, production may again start. The potential market for aspen bedding appears to be good, if the harvesting problems can be worked out.

Door Cores

In 1965, San Pete Forest Products Company opened in Ephraim, Utah. The company planned to produce door cores out of aspen. Timber was made available by the U. S. Forest Service and markets were established. But in 1966, San Pete went out of business. The problem: harvesting costs were too high and not enough timber was brought in during the summer to carry them through the winter. Again, potential is there, but harvesting not economical.

Snow Fences

In 1975, a snowfence company was interested in moving to Utah to make aspen fencing. After working out all the locations, financing and marketing problems, the aspen resource proved to be the stopper. The biggest problem with the aspen seemed to be lack of information on quality and quantity of the resource. No volumes could be guaranteed to the company from U. S. Forest Service, State or private lands because they were not known, especially, in regards to land use planning. Defect was also not able to be determined. Therefore, again, markets were available, but the aspen itself proved to be the detrimental factor for an investment.

FUTURE MARKETS

In the short run, future markets of Rocky Mountain aspen still seem to be best in sawn material. Products such as pallet stock, paneling and mine material will continue to use larger volumes and provide good returns. As was mentioned earlier, mine material probably has the best potential in the expanding coal industry. A big plus for this market is the ability to use lower grade material, which makes-up much of our present aspen stands. Large expected demands for pallets will also make harvesting more economically desirable. Regional demand for pallets will be able to utilize much of the production. This is especially true in Utah, where desirable taxation is promoting large warehouses.

Long run markets need to be further developed, however, there is good potential. One mill in Colorado wants to try aspen shingles. Higher grade boards could go into cash-and-carry stores for shelving. Aspen used for hidden furniture parts is also a potentially good market. The export of aspen logs or products to Japan must also be explored. The Japanese have been buying some aspen logs in British Columbia for furniture stock.

Residue markets also need further exploration. Bedding for livestock from aspen sawdust and planer shavings is

excellent, and should be promoted. Mulching, also seems marketable, especially in light of aspen's rapid breakdown. Aspen residue has good potential in hydromulching and wood flour. These markets, however, would call for some capital expenditure in machinery to breakdown residue into finer particles.

All-in-all the potential of utilizing Rocky Mountain aspen is good. Economics of harvesting will play a key role in determining utilization. It must also be stressed that aspen be sold with its characteristics in mind, otherwise aspen's bad name will continue.

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Market Opportunities And Limitations For Rocky Mountain Aspen[1]

Eugene M. Wengert[2]

SUMMARY[3]

The potential for any large use of Rocky Mountain aspen lumber is limited by (1) high processing costs (2) market limitations imposed by grading rules, (3) high transportation costs to most market areas. As these problems are solved, the outlook should improve. Small market niches do exist at present and can be expanded; these uses include wire spools, cash-and-carry utility lumber, specialized containers, decorative paneling, and mine timbers.

Because of the abundance of conifers and conifer residues, prospects for utilization of aspen for pulp, particleboard, or fiberboard in the Rocky Mountains are not immediate. At present, there are no fiberboard or particleboard plants within the area and only one pulpmill in the Southwest--inaccessible to most of the aspen resource.

Because of aspen's small size and high defect incidence in the core, conventional veneer production has very low potential. There are no plywood mills in the area, although there is one match splint factory that produces veneer for that purpose.

Fuel demand in the Rocky Mountains is quite low as there are few industrial users when compared with other areas in the U.S. Hence, fuel wood has a low potential except within the industry and for fireplace wood.

All indications are that there is good demand for wood residues for animal and poultry bedding. However, most of this demand is east of the Continental Divide while the aspen is west.

The use of aspen for excelsior in the West has been continuing for many years and probably has utilized more aspen sawtimber than any other use. The excelsior industry has been subject to many oscillations in demand. However, with shortages in plastics, it might be anticipated that demand for excelsior will increase.

There are certainly other market niches for aspen--paneling, shingles, stakes, tongue depressors, novelty items, wood flour, and so on--that will continue to use small amounts of raw material and manufacturing residues. These uses should be developed further.

1/ Paper presented at the symposium Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

2/ Extension Specialist, Forestry. Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

3/ This is a summary of some of the information presented in a report in-press by this author entitled, "Guidelines for Utilization and Marketing Rocky Mountain Aspen" to be published by the USDA Forest Service Rocky Mountain Station.

Trends And Prospects For Use In Fiber Products[1]

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ABSTRACT. — About 85 percent of the operating pulpmills in the Lake States use some aspen. In recent years the aspen percentage has varied between 45 and 50 percent of all pulpwood use. Pollution abatement orders may result in some changes in pulpwood use. Aspen has good credentials for use in fiber products. It is light colored, making its use for groundwood pulp attractive. It is readily pulped by any of the commercial processes, and is a raw material most often used in process developments because it is easily pulped. Aspen fiber morphology is excellent. The length-to-diameter ratio and the thin-to-medium-thick walled fibers are particularly suited to enhancing fine paper structure. Its low density is attractive to fiberboard production. The relative low yield per unit cost for aspen probably restricts potential expanded use.

Within the past 25 years we have seen a tremendous increase in the use of all types of hardwoods for fiber product manufacture. While a cost advantage may have been the first and perhaps still is the foremost incentive, certain quality gains were realized so that today hardwood fibers are essential to the satisfactory performance of many fiber products.

In the northern United States aspen has since the early 1940's been the major factor in the remarkable growth in hardwood consumption for pulping.

Recent statistics on aspen use in the Lake States illustrate its importance and availability. Nearly 85 percent of the pulpmills operating in this area use some aspen, and this use comprises some 45 to 50 percent of all the pulpwood consumed (table 1). This speaks well for aspen's use in fiber products since it is estimated to make up about 30 percent of the timber volume.

We are all aware that pressures for pollution abatement are causing wide-scale reevaluations by the fiber products industry. It is too early to attempt to analyze what this may mean for aspen.

Aspen and poplar species in general have been the subject of extensive research throughout the world (Brown, Seager, and Weiner 1957; Roth and Weiner 1964, Weiner and Roth 1970). Much of this research is related to growth, but the general ease in processing and the quality of the resulting fibers and fiber products have made these species somewhat of a standard in the control and evaluation of new products and processes.

WOOD PREPARATION

When aspen first entered pulpwood markets, most was sap-peeled in the woods before shipment. In recent years, preparation has changed dramatically and many pulpmills now practice "hot logging," debark at the mill, and store a limited time. Perhaps the most important factors in the change were the general rise in storage costs and a significant brightness loss resulting from extended storage of peeled logs. Prolonged storage is still practiced when the wood is used in the sulfite or bisulfite process for alleviating potential pitch problems. Other factors were the limited labor market and the lack of accepted portable debarkers. Today we find year-round harvesting and preparation operations for aspen with debarking both in the woods and at the mill.

For debarking at the mill site, mechanical and

[1] Paper was presented at a previous aspen symposium in the Lake States. It was referenced in the Rocky Mountain symposium and is reprinted here because of its particular relevance to the subject.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Table. 1 — *Lake States pulpwood production*
(In thousands of rough cords)

Kind of pulpwood	1965	1967	1968	1969	1970
Hardwood					
Aspen (roundwood)	1,780	1,976	1,753	1,963	1,966
Other miscellaneous (roundwood)	444	539	449	555	658
Residues	8	195	219	259	302
Softwood					
Roundwood	1,268	1,235	1,091	1,139	1,313
Residues	31	20	39	27	46
Total production	3,531	3,965	3,551	3,943	4,285
	Percent	Percent	Percent	Percent	Percent
Aspen	50	50	50	50	46

drum debarkers or combinations thereof are used. Wood cut and delivered during the sap peeling season cleans up quite satisfactorily in one pass, but multiple passes are required for tight-bark seasons. Some operators have found that series installation of debarkers has advantages over recycle systems.

Portable debarking equipment has been added to some woods operations and concentration yards away from the mill site have been developed. New forestry and harvesting practices for optimum management of our wood resource will no doubt force a growth in these types of systems (Benson and Peckham 1968).

Whole tree utilization has potential in the fiber products field. Bark-chip separation techniques will be required for some products. Various methods are under investigation and it is expected that alternatives will be available for both the processor and the user of the wood.

Aspen, when improperly debarked, has been known to cause some operating problems. Perhaps the most troublesome of these is the filling of paper machine wire caused by deposits of stone cells from the inner bark on the wire, a problem similar to the filling caused by resinous woods.

PULPING BY COMMERCIAL METHODS

Pulping, the separation of wood into fibrous elements, is accomplished by mechanical means, by chemical removal of the lignin and incrustants, or by combinations of these two procedures. In each case, the pulp characteristics needed for a particular wood fiber product along with economic considerations determine the choice of the process — groundwood, chemimechanical, semichemical, sulfite, or kraft.

Aspen is readily pulped by any of these commercial processes (Brunson 1964). In fact, it is the wood most often used in development work because of the general feeling that if you cannot pulp aspen with the technique under development, you most likely do not have a viable plan or program. Processing conditions are not uniform from mill to mill for any of the processes, but can be controlled at an optimum for each pulp and fiber product situation. For the optimum, a wood specification such as percentage of rot, size, brightness, or other wood factor could be included. Table 2 gives estimated pulp yields of different species for each of the commercial processes.

The data demonstrates quite clearly the yield advantages of the higher density woods and the importance of including cost in the calculations so that yield per unit cost can be the comparable unit.

Groundwood

Two procedures are available for producing groundwood pulps, which in 1970 accounted for almost 4½ million tons of production in the United States, of which aspen approached 10 percent.

Table 2. — *Estimated yields of pulp for various wood species*

Species	Ovendry wood	Pulping processes					
		Groundwood	Chemimechanical	Semichemical		Sulfite	Kraft
				80 percent yield	60 percent yield		
	Lbs./cord	Cords/ton	Cords/ton	Cords/ton	Cords/ton	Cords/ton	Cords/ton
Aspen	1,825	1.08	1.15	1.31	1.62	1.88	1.97
Black spruce	1,990	.99	1.06	--	--	1.90	1.96
Hemlock	1,990	.99	1.06	--	--	1.95	2.05
Southern pine	2,405	.83	--	--	--	--	1.66
Birch	2,490	--	.85	.96	.83	1.46	1.39
Beech	2,905	--	.76	1.18	1.02	1.54	1.41

The conventional stone grinding process involves holding logs under specified pressures against a rotating grinding wheel of a designated grit size, structure, and surface pattern. Bundles of fibers, individual fibers, and parts of fibers are separated from the log and further ground to form a pulp of desired fiber size distribution and strength. Low-density woods such as aspen are best suited to this process for the production of optimum groundwood quality (Hyttinen, Martin, and Keller 1960; Perry and Canty 1971).

In recent years, a second method for groundwood pulp manufacture has come into significant use. This is the refiner groundwood process which developed primarily as a result of the availability of chips from sawmills or other residue sources (Allan, Skeet, and Forgacs 1968). In this process, the wood chips are reduced to fiber and fiber fragments by refining in a series of attrition mills, commonly called disc mills. The resulting pulps are known by a variety of names — refiner groundwood, disc woodpulp, super groundwood (Richardson and Le Mahieu 1965), and others.

Although the two groundwood pulps are used in similar paper grades, the refiner pulp is usually superior in both tear and bonding strengths, has more long fibers, is poorer by varying degrees in opacity and brightness factors, and usually requires the papermaker to adapt his machine to a change in runnability.

Aspen groundwoods can produce the paper with highest printing quality of any groundwoods and their somewhat lower strength does not materially affect runnability factors on either the paper machine or the printing press.

Chemimechanical

Chemimechanical pulps are the result of a very mild chemical action to delignify and soften wood chips for subsequent refining in a disc mill (Leask 1968) at yield ranges of 80 to 95 percent. Steam-treated pulps characterized by those from the Masonite and Asplund process are included in this category.

The chemical and steam treatments or combinations of the two permit more effective fiberizing and also allow the use of the higher density hardwoods. Certain physical properties are enhanced. These pulps have some use for fine paper but are most used in coarse papers and in many kinds of fiberboard (Fahey and Steinmetz 1971). In this latter category, the low density of aspen is an advantageous factor, especially for the low and medium density fiberboard field. Growth rate in the fiberboard market approaches 10 percent per year.

Semichemical

Semichemical pulps (Vamos, Lengyel, and Mero 1964; Van Eychen 1968) differ from the chemimechanical types by yielding less — 60 to 80 percent. The chemical treatment is somewhat more severe and the subsequent fiberizing requires less power. Some 3½ million tons of semichemical pulps were produced in the United States in 1970 using all types of hardwoods but with negligible aspen use.

Aspen pulpwood, however, is suitable for this process and the resulting pulps are usable in both fine and coarse paper. Almost all of the semichemical pulp tonnage goes into coarse paper grades where the yield per unit cost advantage of the higher density hard-

woods limits aspen use. In the fine papers, kraft and sulfite pulps are preferred.

Sulfite and Kraft

These processes together with bleaching delignify pulps completely and make them suitable for fine paper. The aspen pulp fibers resulting from these processes have special quality characteristics that make them particularly suitable for fine paper structure. They have thin- to medium-thick walls and a length to diameter ratio in excess of 30. While vessel elements are numerous, their diameter is well below that which results in the well-known and disastrous fiber pick problem associated with printing papers containing oak pulp. Thus the fine papermakers, especially those using sulfite pulps, have good reasons to want aspen in their wood procurement plan.

OTHER PULPING METHODS

New pulping methods arise from laboratory and pilot investigations but usually fail to replace those just presented for economic or pulp quality reasons, or both.

Solvent pulping is routinely offered for consideration as a commercial process. A goodly number of solvents together with a hydrolysis reaction will remove lignin from wood, but the processes remain unattractive despite steady promotion in isolated cases.

In general, the commercial potential for new pulping methods must be judged on the basis of the quality obtainable in relation to present methods and the pollution abatement technology economically available for these processes.

It is highly probable that if and when a new pulping process is put through the paces of pilot planting and commercial evaluation, aspen pulpwood would be one of the first wood species to be used.

SUMMARY AND CONCLUSIONS

In summary then, we know that aspen is available and is readily pulped by any of the commercial processes now in use. This fact strongly suggests that if and when pulping processes are changed, aspen will still be a readily usable source of pulp.

The bulk of the aspen pulpwood produced in the Lake States is used in the groundwood, chemimechanical, and sulfite processes. Aspen pulp in these processes provides the pulp quality needed at an economic advantage over other species.

The groundwood pulps are used mostly in printing paper grades. Here aspen provides highest printing quality and opacity without sacrificing runnability on either the paper machine or printing presses. The publication paper segment of the industry recently suffered production cuts but should recover with the general business upturn expected. Small quantities of aspen groundwood are used in tissue at some expense in quality but with economic advantage. This must never be considered a significant outlet.

Chemimechanical pulps are used principally in fiberboards and to a very limited degree in fine papers. In fiberboard, the low density of aspen is an important factor for the low and medium density products. The fiberboard market is expanding at a 5 to 10 percent rate per year.

Aspen is used in sulfite pulpmills for the production of pulps for fine paper grades. Sulfite pulping, however, is in decline and such mills are being shut down. Modifications of sulfite pulping with recovery systems are operating and planned for the Lake States. The real future of this outlet, however, is still cloudy and unpredictable.

Therefore aspen must look to groundwood and chemimechanical pulping for its future. Its advantageous fiber morphology, as shown on table 3, makes it a desirable wood fiber, but its low density is a serious economic disadvantage that limits expansion to other processes and paper grades.

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Table 3. — *Physical and chemical characteristics of five pulpwoods*[1]

Species	Morphology: Fiber length	Morphology: Vessel length	Morphology: Fiber width	Morphology: Wall thickness	Morphology: Fiber volume	Morphology: Vessel volume	Morphology: Ray volume	Cellulose	Lignin	Hemi-cellulose	Density
	Mm.	Mm.	Microns	Microns	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Aspen	0.95	0.55	18-40	2.2	53	33	14	53	16	31	22
Birch	1.20	.95	20-36	2.8	66	21	11	41	19	40	35
Maple	.70	.35	16-30	2.8	61	21	18	41	24	35	35
Spruce	3.20	--	28-40	2.9	93	--	6	44	28	28	24
Southern pine	3.50	--	35-45	3.8	90	--	10	41	29	30	30

1/ Sources of data: Forest Products Laboratory, Rydholm (1965), Joint Textbook Committee of The Paper Industry (1969), Marton and Alexander (1964).

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Rocky Mountain Aspen For Pulp: Some Market Opportunities And Limitations[1]

Thomas J. Loring[2]

Abstract.--Aspen compares favorably with most hardwood species preferred for pulping. Relative abundance and pulping ease contribute to aspen providing more than half of the Lake States pulpwood. Few pulp mills in the Rocky Mountains can now use aspen, and distances limit aspen shipment to mills elsewhere. However, projected rising fiber demand and the need for aspen management in the Rockies should help promote viable markets for pulp and fiber from local aspen.

While it is considered a short-fibered, relatively low density species, aspen compares favorably with most of the hardwood species preferred for pulping. Currently, in the Lake States, aspen is reported as providing more than half of the total pulpwood cut -- amounting to something over 2 million cords of aspen per year.

Undoubtedly, the abundance of aspen fairly close to established pulp mills is a factor in its increasing use in certain areas. Abundance, plus the fact that aspen is readily digested by most pulping processes (with predictable yields of 52% for sulfite, 54% for kraft and produces a pulp suitable for corrugated medium or easily refined for use in book and specialty papers, also are positive opportunities in marketing of aspen for pulping.

A major limitation on marketing aspen for pulp in the Rocky Mountain area at this time is the limited number of pulp mills in the area and the great distances to established mills elsewhere. Almost certainly, other limitations include: financial constraints on modifying or expanding existing pulp mills or constructing new ones, uncertainly as to actual assured volumes of aspen available over the long term, and the fact that rather than producing marketable by-products such as tall oil, aspen pulping tends to produce broken and short fibers which can be a disposal problem.

With the Nation's rising demands for fiber products and some definite moves towards serious management of aspen stands in the Rockies, it appears inevitable that aspen pulp for a variety of markets will be produced eventually in the Rockies. Certainly, aspen can provide considerable volumes of furnish for molded fiber items such as egg cartons, extenders for plastic or composition products, corrugated, medium and even structural particle board -- all of these from relatively unrefined pulp which conceivably could be derived from whole-tree chips produced in the woods.

With further refining, bleaching, etc., aspen pulp can supply all or a major part of the furnish for quality printing and specialty papers. Some recent work even appears to suggest that aspen pulp could be a major source of livestock feed for sheep and cattle.

Background Notes on Pulping Aspen

Relative Yields Percent

Process	Aspen	Ponderosa Pine
Kraft (Sulfate)	54	48
Sulfite	52	45
Groundwood	95	95

Relative Specific Gravity

Aspen:	Green	Air Dry
Quaking	0.35	0.38
Big Tooth	.36	.39

1/ Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976

2/ Forest Products Forester, State and Private Forestry, USFS, Albuquerque, NM

Pine		
Lodgepole	.38	.41
Ponderosa	.38	.40

Average Fiber Length mm

Aspen	
Quaking	1.20
Big Tooth	1.20
Pine	
Lodgepole	3.50
Ponderosa	3.60

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Panel IV.

Research Advances In Aspen Utilization

Moderator: Frederick F. Wangaard

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Some Properties And Characteristics Of Aspen That Affect Utilization In The Rocky Mountains[1]

Eugene M. Wengert[2]

Abstract.--There are large volumes of aspen (*Populus tremuloides* Michx.) in the Rocky Mountain West. The utilization of this aspen is necessary for the management of the aspen type, yet utilization has been minimal. In this report, the aspen tree, the wood's properties, and the wood's processing characteristics are examined, in order to provide up-to-date information and to thereby assist in utilization of Rocky Mountain aspen.

THE ASPEN TREE

The typical Rocky Mountain aspen sawtimber tree is, at maturity, 80 to 100 years old, 60 to 80 feet high, and 11.0 inches d.b.h. or larger (Baker 1925). (There are trees over 200 years old, over 100 feet high, and over 20 inches d.b.h.) Other characteristics of the mature tree are that it has frequently begun to decay in the center (usually caused by *Phellinus tremulae* (Bond.) Bond. et Buris with some evidence of the false timber fungus conks (Davidson et. al. 1959) on the trunk, has a crooked or sweepy stem, and has many knots, especially in the central portion of the stem. A sample of merchantable trees from Southwest Colorado has shown that the average log taper is 0.114 inch per foot of length, approximately 25 percent of the gross scaled footage is defective (about one-half is due to crook and sweep). Bark volume averages about 17 percent of the gross log volume which is higher than the value of 12% for Minnesota aspen. The average double thickness (B) was related to dib at the large end of tree length logs by B = -(0.086) + (.0854) (dib). Bark thickness at any location along the bole was related to dib and dob at that location (Peterson 1961).

$$B = -(0.3168) + (.1046)(dob)$$

and

$$B = -(0.3538) + (.1168)(dib)$$

where B and the diameters are in inches.

Gross volume relationships for aspen trees have also been determined (Peterson 1961) for diameters in inches and heights in feet:

$$V = \frac{[(d.b.h.,i.b^2+36)^{1.1214}(ht.\ to\ 6\text{-}inch\ top,\ dib. - 8.15)^{0.9427}]}{96.3829} + 9$$

where

V = volume, bd. ft. Scribner, to a 6-inch top

and also $$V = \frac{[(d.b.h.,i.b-4)^{.0827+B}(total\ ht.-4.5)^{.4045}]}{2.9655} + .3$$

where

V = volume, cu. ft., to 4-inch top (d.i.b.)
$B = .6593 \log_{10} (total\ ht. - 4.5)$
d.b.h.,i.b = 0.8954 (d.b.h.,o.b.) + 0.3168

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[1] Paper presented at the symposium Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

[2] Extension Specialist, Forestry. Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. Formerly technologist with the U.S. Forest Products Laboratory stationed at the Rocky Mountain Forest and Range Experiment Station, Ft. Collins, Co. This research was sponsored jointly by the USDA Forest Service's Forest Products Laboratory, the Rocky Mountain Forest and Range Experiment Station, and the Intermountain Forest and Range Experiment Station.

This latter equation has been successfully applied to aspen from Utah, Colorado, and New Mexico by the author.

PROPERTIES

Structure

Since aspen belongs to the hardwood, or broad-leafed class of trees, the wood has numerous pores (vessels) scattered among the fibers. The pores are very small, however, being barely visible with the unaided eye. The pores are fairly uniform in size throughout the annual ring, although they become slightly smaller toward the end of the growing season. As a result, the annual rings are distinctly but not conspicuously defined. The rays are extremely low and narrow, being only one cell wide. The fibers, the most abundant cell, are much shorter than softwood fibers, 3-4 times shorter. The result of these characteristics is that aspen is very uniform in texture, structure, and appearance.

Aspen has many loose knots that may break or fall out during processing. Aspen also has tension wood scattered throughout the stem which causes some processing problems (Kennedy 1968).

Color, Odor, and Texture

Usually the wood of aspen, both heartwood[3] and sapwood, is quite white. However, there are discolorations around knots and in the center portions of the tree, often attributed to bacterial wetwood and to the early stages of heart rot.

Aspen wood is practically tasteless and odorless when dry. When wet, aspen wood, especially bacterial wetwood, has a distinctive and sometimes slightly unpleasant odor. Aspen is a soft, virtually splinterless wood.

Specific Gravity and Weight

When green, aspen weighs 43 pounds per cubic foot on the average. Wetwood can increase this to 50 pounds or more per cubic foot. At 12 percent moisture content, aspen weighs 27 pounds per cubic foot.

The weight of aspen, 1-1/8-inches thick at 20 percent moisture content is approximately 2774 pounds per thousand board feet. Aspen lumber, surfaced to 25/32-inch, would weigh approximately 1760 pounds per thousand board feet at 12 percent moisture content (Johnson 1947).

One cord of aspen pulpwood with the bark weighs 4075 pounds (approximately) green. A cord contains approximately 607 pounds of green bark at 95 percent moisture content.

A specific gravity of 0.38 (green volume, ovendry weight) with a range of at least $\pm.08$ is the most accurate for Rocky Mountain aspen based on the author's unpublished data at the Rocky Mountain Forest and Range Experiment Station. This is the same as for Lake States' (Erickson 1972) and Canadian aspen (Kennedy 1965).

Due to the action of bacteria in bacterial wetwood, the specific gravity of wetwood is found to be 0.03 to 0.04 lower than for normal aspen wood (Haygreen and Wang 1966 and Kennedy 1974). Tension wood will increase specific gravity 0.02 to 0.06 units (Kennedy 1968).

Aspen bark specific gravity is approximately 0.45 with a range of 0.38 to 0.57.

Green Moisture Content

The moisture content of the standing tree is quite variable, depending primarily on the season and whether wetwood is present. Normal sapwood values range from 65 percent or higher in the summer to 90 to 110 percent in the winter; wetwood values can run as high as 160 percent (Bois 1974 and Yerkes 1967). Heartwood values are approximately 10 to 20 pet. m.c. lowes than sapwood.

Shrinkage

Aspen has a fairly low shrinkage--3.5 percent (green to ovendry radial), 6.7 percent tangential, and 11.5 percent volumetric (FPL 1974). The large tangential to radial shrinkage ratio means that aspen will be subject to cupping and diamonding when moisture content changes occur in drying and in use.

Longitudinal shrinkage is usually ignored for most species, but for aspen, which has an abnormal amount of tension wood, longitudinal shrinkage can be significant--0.16 to 0.72 percent, green to ovendry (Kennedy 1968). This longitudinal shrinkage means that aspen will be subject to bowing, crooking, and veneer buckling when moisture content changes occur in drying and in use.

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[3] It is the author's general observation that Rocky Mountain aspen contains considerably more heartwood than Lake States aspen.

Strength and Mechanical Properties

Values of strength are given in Table 1, design values in Table 2.

Nailholding Power

The average holding power of a sevenpenny, cement-coated nail driven 1-1/4 inches into the side grain of dry or green aspen is about 194 pounds. The same nail driven into green aspen is only about 20 pounds after the wood has thoroughly dried (Johnson 1947).

The nailholding power of aspen is comparatively low. To compensate for this, more or larger diameter nails with larger heads can be used to obtain higher power. Fortunately, aspen has very little tendency to split when nailed and this makes up for some of its low nailholding power.

Gluability

Laboratory tests and experience have shown that aspen is one of the easiest species of wood to glue. However, aspen is quite absorptive, so rapid assembly is required. With some adhesives, water must be added to prevent premature drying of the adhesive.

Finishing

Aspen is one of the best hardwoods for paint holding ability (Zasada 1947). Of course, knots must be carefully primed. Aspen also takes stain very well, but uneven adsorption causes a "blotchy" appearance. A wash coat or sealer application prior to staining will alleviate this problem. Aspen also accepts ink very well.

PROCESSING

Machining and Related Properties

Maching is a broad term that includes sawing, planing, shaping, sanding, boring, and the like. Aspen machines easily in that power consumption is low and tools are not dulled rapidly. However, it is difficult to obtain a good surface on aspen, unless special care is taken. Aspen's fibers sever less cleanly than most other woods, due in part to tension wood, thereby leaving a fine fuzz on the surface. Excellent turnings, borings, and sanded surfaces can be obtained if the following procedures are followed where appropriate (Davis 1947 and 1962, Stewart 1973, Wengert 1973)

(1) Moisture content, 6 percent or less.
(2) Knife angle, 25° to 30°.
(3) Feed rate or lathe speed, slow (22 cuts per inch in planing).
(4) Cutter head speeds, high--peripheral speed above 5000 fpm.
(5) Revolve work against the knife direction in lathe or feed lumber so cutter head moves with the grain in planing.
(6) Use a shallow, 1/32-inch, final cutting depth.
(7) Plane lumber across the grain.
(8) Boring should be done using a slow feed speed.
(9) Very fine sanding increases fuzz.

Based on only a small number of tests, it appears that wetwood aspen machines more poorly than normal aspen.

The fuzziness that is common to aspen can be removed by proper sanding procedures, by using special abrasives, by using an antifuzz sealer, or by using a wash coat before final sanding.

In short, with extra care aspen can be machined to give excellent surfaces.

DECAY RESISTANCE

Both the heartwood and sapwood of aspen are low in natural decay resistance. Untreated aspen posts or lumber in contact with the soil may last only two or three years. Due to the low, permeability of aspen wetwood and heartwood, some difficulty is experienced in getting aspen to accept a uniform preservative treatment (Cooper 1976). Usually the small diameter logs treat best. With a suitable treatment, aspen can give very good service in moist locations (Kaufert 1948).

Table 1.--Mechanical properties of aspen (*P. tremuloides*)

	Specific gravity	Moisture content at test	Static bending					
						Work (in. lb./cu. in.)		
	Green vol.	Percent	Stress at P.L. (psi)	Modulus of rupt. (psi)	Modulus of elas. (psi)	To P.L.	To max. load	Total
Normal SG	0.37	green	2900	5500	1,310,000	0.37	6.9	20.2
Low SG	.35	green	--	5100	860,000	--	6.4	--
Normal SG	.37	12	5200	9800	1,630,000	.99	10.3	21.0
Low SG	[1] .37	12	--	8400	1,180,000	--	7.6	--
Wetwood	[2] .329 [3] .357	green	2666	4973	612,000	--	--	--

	Compression parallel to grain			Compression perpendicular to grain	Hardness (lb.)		Shear parallel to grain	Cleavage	Tension perpen. to grain	Toughness (5/8-in. sq. sample
	Stress at P.L. (psi)	Max. crushing stress (psi)	Modulus of elas. (psi)	Stress at P.L. (psi)	Side	End	Max. stress (psi)	(lb./in.)	Max. stress (psi)	(in.-lbs.)
Normal SG, green	1510	2350	1,250,000	200	320	340	720	180	440	[4] 165
Low SG, green	--	2140	2,140,000	180	300	--	660	--	230	
Normal SG, 12%	3280	5270	5,270,000	510	480	630	980	260	610	[4] 115
Low SG, 12%	--	4250	--	370	350	--	850	--	260	
Wetwood, green	1428	1878	525,000	--	--	--	--	--	--	

[1] Specific gravity 0.38 at 12% moisture content.
[2] Comp. II
[3] Bending.
[4] Specific gravity = 0.39

Sources: Low specificific gravity -- FPL 1974; Normal SG--Kennedy 1965; wetwood--Haygreen and Wong 1966.

Table 2.--Recommended design values (PSI)[1] for WWPA graded lumber (WWPA 1974)

	Extreme fiber stress in bending "Fb"		Tension parallel to grain "Ft"	Horizontal Horizontal shear "Fv"			Modulus of elasticity "E"
	Single	Repetitive			Perpendicular $"Fc_1"$	Parallel "Fc"	
Light framing and studs - 2" to 4" thick, 2" to 4" wide							
Construction[2]	650	750	400	60	185	625	900,000
Standard[2]	375	425	225	60	185	500	900,000
Utility[2]	175	200	100	60	185	325	900,000
Studs	500	575	300	60	185	325	900,000
Light framing - 2" and less in thickness, 2" wide							
Construction	600	700	325	60	185	625	900,000
Standard	275	325	150	60	185	500	900,000
Utility	75	100	50	60	185	200	900,000
Light framing - 3" and less in thickness, 3" wide							
Construction	550	625	300	60	185	625	900,000
Standard	350	400	200	60	185	500	900,000
Utility	100	125	50	60	185	250	900,000
Structural light framing and appearance - 2" to 4" thick, 2" to 4" wide							
Select structural	1300	1500	775	60	185	850	1,100,000
No. 1/appearance	1100	1300	650	60	185	675/825	1,100,000
No. 2	925	1050	525	60	185	550	1,100,000
No. 3	500	575	300	60	185	325	900,000
Structural joists and planks and appearance - 2" to 4" thick, 6" and wider							
Select structural	1150	1300	750	60	185	750	1,100,000
No. 1/appearance	950	1100	650	60	185	675/825	1,100,000
No. 2	775	900	525	60	185	575	1,100,000
No. 3	450	525	300	60	185	375	900,000

[1]These design values apply to lumber when used at a maximum moisture content of 19% such as in most covered structures.

[2]Fb, Ft and Fc recommended design values apply only to 4" widths of these grades.

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Research Advances In Aspen Utilization For Pulp[1]

Eugene M. Wengert[2/]

SUMMARY

Aspen (Populus tremuloides Michx.) is widely used for pulp in the Lake States and in Canada. Several recent reviews of aspen for pulp and research needs have been compiled (Auchter 1972, Keays et. al. 1974, and Neilson 1975. Since Auchter's paper provides a concise review of current pulping technology that should be applicable to Rocky Mountain aspen, it is reprinted here in full.) Lack of basic research information does not appear to be a major barrier to the use of Rocky Mountain aspen for pulp. However, if aspen is to be blended with the indigenous conifers, operational parameters will have to be established to achieve suitable pulp quality. Likewise, various tree diseases common in Rocky Mountain Aspen will affect pulp yield and pulp quality to a small extent. Disease losses would contribute primarily to decreased yield per unit cost, affecting the merchantability of some stands. In short, any lack of use of aspen for pulp in the Rocky Mountains will stem basically from marketing and/or economic considerations.

1/ Discussion presented at the symposium Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

2/ Extension Specialist, Forestry. Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. (Formerly with USDA Forest Service, Forest Products Laboratory)

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Lumber Yield From Rocky Mountain Aspen[1]

Eugene M. Wengert[2]

SUMMARY

Aspen (Populus tremuloides Michx.) is an underutilized species in the Rocky Mountain West. Colorado has more aspen sawtimber than any other state, but its annual harvest of aspen sawtimber for use in sawn products is less than 5 million board feet. Although many factors contribute to this underutilization, one important reason is the unfamiliarity with the species and the product potential of standing timber or logs. The purpose of this study was to develop and evaluate a method of determining this potential for board or mine timbers and dimension lumber.

In this study aspen trees from northern New Mexico and eastern Utah were graded, based on d.b.h. and on the presence and frequency of conks and scars, were then felled and sawn into 8-foot logs. The logs were graded on the basis of decay, sweep (or crook), and scaling diameter. The logs were then sawn into boards, dimension lumber and mine timbers. Sawn product recoveries, both volumes and dollar values, were related to tree and log grades. Both grading systems were able to separate trees and logs into different recovery levels--volume and dollar value.

The log grades performed well in New Mexico for separating the logs into definite value classes ($ per 100 cu. ft.), recovery classes (both log recovery factor (LRF) and percent of log volume converted to lumber), and lumber grade recovery (yield of #2 and #3 Common and better). In Utah, the log grades were less effective in predicting LRF and volume recovery. However, they correlated better with lumber grade recovery (yield of #2 Dimension and Better and mine posts) and dollar value.

The full results of this study will be published in a technical report, to be issued by the Rocky Mountain Forest and Range Experiment Station.

1/ Paper presented at the symposium Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

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Processing Low Quality Trees By The SHOLO Approach[1]

Vern P. Yerkes[2]

Abstract.--(SHOrt LOg) processing can alleviate some critical problems of processing aspen into a marketable product. High quality bolts (<8') are bucked from each log to the length required by the target product. Only quality blocks are then transported to and handled at the processing mill. This system has proven effective in pallet part production in the eastern U. S. Successful implementation of the SHOLO system requires careful analysis of seven key planning steps. Identification of the target products is essential so all primary processing is directed to these products without need for a secondary processing system.

The Colorado State Forest Products Bulletin of July 1976[3] contains a statement which graphically portrays some critical problems of processing Aspen into useful consumer products.

> "...merchantable volume is significantly limited by a combination of characteristics which also results in higher processing costs (1) a high proportion of crooked small diameter trees and (2) a high incidence of decay occurring in overmature stands."

The impact of these characteristics can be markedly reduced through high-speed processing of short logs (<8') directly into a marketable product without first processing long logs then remanufacturing lumber into the product.

The suggested approach is to buck low quality crooked stems into short blocks cut to the dimension (length) needed in the target product. All crook possible is bucked out producing short straight blocks. Also any defect not acceptable in the target product can be bucked out. This would mean that only the higher quality sections of the tree would be processed into the product. All other pieces would be relegated to the chipper (or other lower valued product) in the round log form. The operator incurs no unnecessary processing costs by handling those sections of the tree that were unsuited for his product.

This approach to processing low quality and low valued hardwoods has been termed "SHOLO" for SHOrt LOg processing. The concepts have been evaluated by scientists of the Northeastern Forest Experiment Station at the Princeton Forest Products Marketing Laboratory at Princeton, West Virginia. They have also provided a technique of evaluating the economic feasibility of a proposed venture for a given set of circumstances of target product, processing system and raw material source.

You need to have a number of things in mind before such a proposed system should be started:

(1) The product objective must be defined by dimensions and grade if possible. Quality limitations of the round log must be identifiable. Pallet stock, furniture squares, match-block, etc. may be potential products.

1/ Paper presented at the symposium: Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

2/ Multi-Regional Harvesting Specialist, USFS, Region 3, State & Private Forestry, Albuquerque, New Mexico

3/ July 1976 Colorado State Forest Service, Forest Products Bulletin V 10 #3.

(2) Sale value of products must be established.

(3) Market values of residues, if present, must be established for both the defective section of stems bucked out and processing residues of the high quality bolts. Pulp chips--cattle feed--bedding flakes, firewood, etc. would be potentials for consideration.

(4) Potential recoveries of usable high quality bolts and residues must be evaluated as a percent of total volumes handled. A specific cruise, etc. may be necessary to determine this.

(5) A processing system must be planned to allow processing of the tree stems at a volume rate and estimated cost to meet the objectives of the firm undertaking the venture. Consider various types of breakdown methods--scragg saw, band saw, gang saw, slab saw, trim saws, etc. that could be used to convert the short blocks into the target product. Consider also various possible combinations of equipment.

(6) An economic analysis must be made to determine if a given system can in fact economically process the available raw material into the target products. If determined not economical, either redesign the processing system into a more efficient configuration or combination of equipment or drop the proposal altogether.

(7) If the above proposal appears economically feasible, then complete design and layout of the processing system and begin construction.

It may take two or three tries at finding an economical processing unit or system or balance of principal breakdown equipment and secondary processing units but it is important to do this to set up the most efficient system possible for the available resource and target products. Remember we are dealing with a low value log to start with so need to be as efficient as possible.

The physical processing of a low quality tree would be as follows:

1. Fell tree and buck, from between defects (if any), all possible high quality blocks that will produce the target product. This may be done at the stump or at a landing or by processor or the tree may be handled full length to the mill for debarking before bucking.

2. Transport product blocks to mill. Transport defective pieces to a chipper, flaker, splitter, etc. for processing.

3. Breakdown blocks into product dimensions. This can be done by a 2 or 4 saw circle scragg, twin or quad band saws or standard circle or band saw with appropriate resaw equipment, whichever results in the lowest production costs for the firm's objectives.

Three methods of log breakdown are discussed by Coleman and Reynolds in their 1973 paper NE-279 Sawing SHOLO Logs: Three Methods.

They found that both yields of products and width recovery are affected by the type of breakdown and amount of effort expended to recover material from slabs.

This system has proven effective in the production of pallet parts from low quality trees in the eastern U.S. The high speed production of single pass systems can more than offset the low quality and potentially high defect volume of these stands.

The key element in the process is the identification of the target product(s) with all processing, from the stump, directed toward those products without going through a secondary processing system.

Annotated Bibliography

1973 Coleman, Ronald E. & Hugh W. Reynolds
Sawing SHOLO Logs: Three Methods.
USDA Forest Service Research Paper NE 279
Northeastern Forest Experiment Station
6816 Market St., Upper Darby, PA 19082

A discussion of the results of testing 3 breakdown methods for SHOLO logs.

(1) Selective method - logs are sawn through and through on a standard circle or gang sawmill.

(2) Gang method - 4-sided cant produced on a 4-saw circle scragg or quad band then the cant was gang sawed.

(3) Combination method - same initial breakdown as in 2 but with addition of slab resaw and edger saw.

Highest volume recovery was from selective or combination methods. The selective method produced highest proportion of wider boards.

1970 Reynolds, Hugh W. & Charles J. Gatchell
The SHOLO Mill: Make Pallet Parts and Pulp Chips From Low Grade Hardwoods
USDA Forest Service Research Paper 180 NE
Northeastern Forest Experiment Station
6816 Market St., Upper Darby, PA 19082

Presents the details of one example of a processing system to produce pallet shook from SHOLO material from low-grade trees. This is only one example that uses sizeable investments with large volume needed to show a profit. Other systems using lesser investment costs and lower volume demands can produce same results.

1971 Reynolds, Hugh W. & Charles J. Gatchell
The SHOLO Mill: Return on Investment Vs. Mill Design
USDA Forest Research Paper NE 187
Northeastern Forest Experiment Station
6816 Market St., Upper Darby, PA 19082

Presents the analytical techniques used to evaluate the profitability of a proposed set of circumstances including mill design, product objectives, and raw material source. Presents method with nomographs and instructions to complete the analysis.

1972 Yerkes, Vern P.
SHOLO Can Help Make Use of Low-Quality Logs.
Forest Industries V 99 #11 p. 40-41
Oct. 1972

Presents an introduction to the SHOLO mill concepts and planning process for mill design and establishment.

Kiln Drying Characteristics Of Studs From Rocky Mountain Aspen And Wisconsin Aspen[1]

James C. Ward[2]

Abstract.--Aspen studs, 7/4-inch thick, from Rocky Mountain and Wisconsin trees will dry to required moisture contents within similar periods of time under conventional and high temperature kiln schedules. Bacterial wetwood occurs in both Rocky Mountain and Wisconsin aspen and causes severe drying problems from wet pockets, collapse, honeycomb, and ring failure. Presorting green lumber is a suggested solution to the wetwood problem.

SUMMARY

Comparative studies were made of the kiln drying characteristics and related wood properties of aspen from the Rocky Mountains and from Wisconsin. Wisconsin aspen includes both bigtooth and quaking aspen, but quaking aspen is the sole Rocky Mountain species. All sample material was sawed in the form of 2 x 4 studs (1-3/4 inch green thickness) and kiln dried green from the saw under conventional and high temperature schedules commonly used to dry softwood dimension lumber. The conventional schedule had initial dry-bulb (DB) and wet-bulb (WB) temperatures of 180°F and 170°F, respectively. Initial conditions for the high temperature schedule were 235°F (DB) and 200°F (WB). One charge of bigtooth aspen studs was dried with a borderline schedule of 212°F (DB) and 198°F (WB).

Total drying times for aspen studs to reach final required moisture contents less than 19 percent varied by schedule and by the type of wood in each piece. Three types of wood, sapwood, heartwood, and wetwood, were found to occur in both Rocky Mountain and Wisconsin aspen. Given equal drying conditions and comparable types of wood, Rocky Mountain and Wisconsin aspen will dry to required moisture contents within similar time periods.

Sapwood dried at the fastest rate and wetwood at the slowest, while heartwood had an intermediate, but wide range of drying rates. Under high temperature conditions, average times for sapwood, heartwood, and wetwood to dry to 15 percent moisture content were 17, 25, and 30 hours, respectively. The conventional schedule required an average of 90, 115, and 179 hours to dry sapwood, heartwood, and wetwood to 15 percent moisture content. Average drying times using the borderline schedule, 212°F (DB) - 198°F (WB), were only 25 to 30 percent less than drying times under the conventional schedule. Eastern hemlock and white fir dimension lumber, 1-3/4-inches thick, were found to have similar drying times, indicating that aspen studs can probably be kiln dried in mixture with softwoods.

During drying, wetwood in both Rocky Mountain and Wisconsin aspen invariably developed collapse, honeycomb, ring failure or a combination of these three. Sapwood and heartwood did not develop these types of degrade even when subjected to high temperature drying conditions. Wetwood studs dried under the conventional schedule did not appear to have less degrade than wetwood studs dried under higher temperatures.

It is postulated that anaerobic bacteria are responsible for wetwood formation in living aspen trees. Most examples of wetwood formation in Wisconsin aspen could be traced to bacterial invasion of inner or dying sapwood, while wetwood in Rocky Mountain aspen could generally be traced to bacterial invasion of established heartwood. Wetwood-associated bacteria also contributed to the drying problems. Retarded drying rates in wetwood are attributed to occlusion of vessels by bacterial slime and

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1/ Paper presented at the symposium, Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, CO, Sept. 8-9, 1976.

2/ Research Forest Products Technologist, Forest Products Laboratory, USDA, Forest Service, Madison, WI.

related by-products. It should be noted, however, that non-infected heartwood dried at a slower rate than sapwood because of tyloses formation in vessel lumens. Pectin-degrading anaerobes, especially those in the genus Clostridium, were consistently isolated from aspen wetwood and are believed to cause an enzymatic weakening of the bonds between wood cells, thus resulting in collapse, honeycomb, and ring failure.

Problems associated with the drying of wetwood are the major obstacles to successful utilization of aspen for studs. Until such time that techniques can be developed for adequate drying of mixed kiln charges, the best solution to the wetwood problem is to sort out the wetwood studs from studs with normal wood and then dry the various sorts under different methods. This study indicates two wood properties, electrical resistance and green weight, should be investigated further as factors for presorting wetwood.

Aspen Wood And Bark In Animal Feeds[1]

Andrew J. Baker[2]

Cellulose is the most abundant, naturally renewable material on earth. It and hemicellulose make up about 70% of the dry weight of shrubs and trees. The cellulose of woody plants, however, is largely unavailable to ruminants because of the highly crystalline nature of the cellulose molecule and the existence of a lignin-carbohydrate complex.

The digestibility of aspen wood by ruminants has been estimated to be about 35%. In dairy cow feeding experiments, ground aspen wood appears suitable as a partial roughage replacement in high-grain dairy rations. This would be practical for dairy cows, however, only if other roughages are not available.

The digestibility of aspen wood, and presumably aspen bark also, can be increased to approach the theoretical maximum by various physical and chemical pretreatments.

Aspen bark appears to be equivalent to medium-quality hay if properly supplemented. Its use in sheep and beef cow rations should be considered if other sources of feed are expensive or unavailable.

1/ Paper presented at the symposium Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

2/ Chemical Engineer, U.S. Forest Products Laboratory, Madison, Wis., 53705. The Laboratory is maintained in cooperation with the University of Wisconsin.

The use of whole-tree aspen in growth rations for beef animals is being investigated by L. D. Kamstra, Animal Science Department, South Dakota State University, Brookings 57006. Information on methods of preparation and supplementing aspen bark for wintering rations for beef cows is available from R. D. Goodrich, J. C. Meiske, and J. W. Rust, Department of Animal Science, University of Minnesota, St. Paul 55108.

The following reports on wood and bark in animal feeds are available from Forest Products Laboratory, Forest Service, USDA, P.O. Box 5130, Madison, Wis. 53705:

Baker, Andrew J., Merrill A. Millett, and Larry D. Satter, 1975. Wood and wood-based residues in animal feeds. p. 75-105. In Cellulose Technology Research, Albin F. Turbak, ed. Am. Chem. Soc. Symposium Series 10, Am. Chem. Soc., Washington, D.C.

Fritschel, P. R., L. D. Satter, A. J. Baker, and others, 1976. Aspen bark and pulp residue for ruminant feedstuffs. J. Animal Sci. 42:1513-1521.

Colorado Steers And Aspen Bark[1]

Julius A. Fullinwider[2]

Abstract.--To assess the practicality of increasing the value of aspen fiber through use of its bark as a livestock feed, feeding trials were conducted at a Colorado feedlot. Weight gains and carcass grades were slightly lower in steers fed aspen bark than those fed alfalfa roughage. Further livestock feeding research is needed to resolve palatability problems encountered.

INTRODUCTION

Western Colorado has 2.3 million acres of aspen type totaling 5.1 billion board feet of aspen sawtimber (Green and Setzer, 1974). Aspen in the Rocky Mountains is generally considered a low profitability species primarily because of, but not limited to, its small diameter at maturity, its crookedness, its low quality due to knots and a general lack of markets for products. Aspen is often the first stand to become established after a disturbance such as fire, logging, or avalanche. It often serves as a "nurse" cover for relatively shade-tolerant conifers such as spruce and fir. If left unmanaged, areas with this short-lived aspen cover will eventually revert to conifers.

Perpetuation of aspen is needed to benefit the following resources:

- To provide habitat for elk, deer, black bear, beaver, woodpeckers, flamulated owl and other non-game animals and birds.

- For aesthetics, which are enhanced by fall color and landscape variety in form and texture.

- To serve as living firebreaks between conifer stands.

- To enhance recreation experience by maintaining a variety of wildlife and plants.

- For watershed improvement provided by fast-growing and extensive lateral root system of aspen.

It is the premise of the work described herein that profitable utilization of aspen bark will encourage total utilization and improve the economic picture for the species and, therefore, will aid in the management of the species. In addition to forest management benefits, the use of aspen bark to replace hay in rations would help to alleviate hay shortages, especially during dry years, and might reduce feed costs in locations far from hay-growing areas.

Using aspen bark for feed is economically appealing because (a) debarking is a common practice at wood processing plants, (b) bark has an associated disposal cost at the mill and (c) handling and pelletizing costs for feed are minimal. Total manufactured costs for aspen bark are estimated to be $30 to $40 per ton for a commercial operation compared with hay costs of approximately $65 to $85 per ton.

PAST FEEDING STUDIES

Interest in feeding wood to ruminants as a roughage and an energy source dates back to 1920, when Douglas fir and eastern white pine sawdust were fed to sheep and dairy cows (Baker, Millett, Salter, 1975). However, only the University of Minnesota and the University of Wisconsin have reported feeding trials and experimental testing of aspen bark. The desirability of aspen bark for deer, elk, and beaver is well-noted.

1/ Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Fort Collins, Colorado, September 8-9, 1976.

2/ Forest Products Specialist, USDA-Forest Service, Denver, Colorado.

The University of Minnesota trials involved ensiling the bark before feeding to 15 sheep in three different amounts (Table 1). The bark was not pelleted. Chemical composition of the ensiled poplar bark (moisture free) was measured and is shown in the following tabulation:

Chemical composition of ensiled poplar bark (moisture free)

Crude protein	2.2%
Crude fiber	53.7%
P	.03%
K	.22%
C_a	1.16%
N_a	.003%
M_g	.09%
F_e	74.1 ppm
2_n	140.0 ppm
C_n	7.7 ppm
M_o	0.1 ppm
M_n	21.0 ppm
B	12.7 ppm
S_v	44.1 ppm

Digestibility, determined by differences when compared with a basal mixture, was 36.7% (± 1.66 standard error) on a dry-matter basis. The digestibility of hay is around 55%, depending upon its quality.

Table 1.--Performance and ration of University of Minnesota trial for 13 through 48 days

Number of sheep	5	5	5
Average daily feed, kg			
Aspen bark[1]	1.78	1.54	1.34
Soybean meal	.23	.13	.045
Oats	--	.34	.068
Average daily weight gain, kg	.043	.034	.035

1/ 44.4% dry matter

The University of Wisconsin has also reported good success with aspen bark fed to goats (15%, 30%, 45%, and 60% in ration) and has reported higher digestibilities (50%). Further work with sheep at the University of Wisconsin has confirmed these results although, from time to time, some palatability problems were encountered with the sheep.

Trials ending in September 1975 at the University of Saskatchewan in Canada showed that steam and alkali treatments were not successful in raising aspen bark digestibility above 30%.[3]

In the spring of 1975, a pilot test of aspen bark feeding as the roughage component of a finishing ration at a feedlot in Montrose, Colorado was initiated. About the same time, aspen feeding trials were planned at South Dakota State University.

TRIAL PREPARATION

Plans

Between March 12, 1975, and June 5, 1975, a project plan, financial plan, cooperative agreement between USDA-Forest Service and Collins Farm feedlot at Montrose, and a cooperative agreement between Collins Farm and participating cattlemen were written.

Bark Procurement

Several logging operations in the Montrose area were cutting aspen on mixed species timber sales. American Excelsior was the one operation cutting only aspen. Their process called for complete removal of all sizes of trees, decking in Olathe, debarking and cutting into 100-inch bolts for later shipment to their Denver plant. A Rosser-type debarker, with a high wood content residue, was in use at this location.

A ring-type debarker, which produced cleaner bark and had higher bark recovery possibilities, was located at Silver Tip Studs in Montrose. Arrangements were made to have the American Excelsior aspen logs delivered to Silver Tip Studs and debarked at a cost of $4 per thousand board feet. Twice during the summer the logs were decked, scaled and debarked to obtain bark volumes needed for the feeding trials. Logs were debarked from two different sources: Little Cone Mountain near Sawpit, Colorado, and the Buckhorn area near Ridgeway, Colorado

The bark was easily removed and ranged in size up to three square foot strips. No

3/ Unpublished study

evidence of any disease was found. Some wood, particularly knots, was broken off by the debarker, but was removed before the bark was pelleted. Bark samples were taken frequently throughout debarking, placed in an air-tight container, and shipped to Fort Collins for moisture content analysis. Next the bark was trucked from the collection hopper to a drying area.

Little Cone Mountain bark was dried in a lumber dry kiln with fans operating and kiln doors left open. No heat was applied. Buckhorn bark was air-dried in piles at one end of the Silver Tip Studs log yard. Air drying was found to be the most feasible way to handle the large volume of bark. Several days of 70°+ weather were required to dry the bark from 95% moisture content (oven-dry basis) to 15%. Without periodic "mixing", piles of bark heated to some extent. Spreading bark on an asphalt surface for rapid drying would be suitable, alleviating the need for mixing. A rotary corn dryer would probably be the best method for bark drying.

Bark sample data follows:

	Little Cone	Buckhorn
Scaling sample yield:		
No. of logs	130	155
Bark Volume	503.28 ft^3	434.86 ft^3
Wood Volume	2427.13 ft^3	2296.06 ft^3
Bark % of Total	17%	16%
Moisture content:1/		
Ave.	95%	91%
Range	60%-122%	78%-116%
Specific gravity		
Ave.	0.448	not
Range	0.38-0.57	determined
Total yield:		
No. of logs	165	686 2/
Bd. ft. (Scribner)	14.1M	43.4M
Green tons of bark	9.6 tons 3/	28.5 tons 3/

1/Obtained from bark conveyor samples and log deck samples. Moisture content is oven-dry basis, rather than original-weight basis. For instance, an oven-dry M.C. of 100% would be an original-weight M.C. of 50%.
2/Exclusive of 39 logs with no bark.
3/These figures represent about 75% of total bark tonnage. About 25% of the bark was lost in handling prior to debarking due to bark slippage on logs cut during the spring.

Bark Processing

Pelleting the bark roughage was determined to be the most accurate and easiest way of handling and measuring. Ute Mills of Montrose was very cooperative in processing the aspen bark. No major problems were encountered. Hammermilling of the bark caused more stress on the equipment than pelletizing. Moisture content of the bark was critical during hammermilling and needed to be near 15%. Both 1/4-inch diameter and 3/8-inch diameter pellets were made with no additives. The 3/8-inch pellet was used in the trials as recommended by Dr. John Matsushima of Colorado State University. Aspen bark was processed and delivered by Ute Mills upon request from the feedlot throughout the trials. Pellets were stored in sacks inside a building at the feedlot.

Cost of Aspen Bark Pellets

	Cost/Ton
Debarking	
20.35 tons processed	$11.43
.65 waste	
21.00 tons total	
Hauling (storage and drying)	3.10
Hammermilling and pelletizing	18.00
Handling (from storage to mill and feedlot)	2.00
	$34.53

Raw aspen bark spread for drying

Hay Procurement and Processing

Sun-cured alfalfa hay was purchased through Ute Mills. All hay was assumed to be equal in protein content. The hay was processed through the same mill and 3/8-inch diameter pellets were delivered to the feedlot as requested.

Hay Cost	Cost/Ton
Hay	$65.00
Pelletizing	18.00
Handling	2.00
	$85.00

Procurement of Steers and Feedlot

A well-operated feedlot with good record-keeping procedures was located in Montrose, Colorado. Collins Farms feedlot feeds several thousand cattle annually, has up-to-date equipment and techniques and was willing to cooperate in the project.

Two-hundred steers were solicited through local ranchers to fill the four feeding trial pens. The steers were split into pens as evenly as possible by breed, owner, and weight. The following livestock owners cooperated in the trials: Currier, Collbran (100 head), Hughes Brothers, Norwood (28 head), Raymond Snyder, Norwood (22 head), Jack Dixon, Gunnison (25 head), and Collins Farms, Montrose (25 head).

Public Information

An information booth was set up for display at the Colorado Cattlemen's Association convention, June 19-21, 1975. The purpose of the booth was to inform convention attendees of the why and how of the aspen bark trials. The booth consisted of a series of photos showing the processing of the bark from tree harvest to cattle feeding. Samples of raw, hammermilled and pelleted bark were available for observation. Some people actually tasted the pellets and decided they might be taster's choice to a beaver, but definitely not to them, personally. Literature describing these trials and similar research was available to the public. To answer any questions that might arise, the booth was manned by Forest Service personnel Tom Weldon, Jim Free and Wendell Turner.

Information regarding the trials appeared in Montrose, Grand Junction, and Denver newspapers. Additional articles appeared in other magazines and newspapers.

FEEDING TRIALS

Dr. Matsushima designed the initial feeding ration for the trials, monitored the division of steers into pens, made later feeding ration changes and graded carcasses at the end of the trials.

The two-hundred yearling steers were divided into four pens. Two of the pens were to be fed aspen pellets as roughage and the other two were to be fed alfalfa pellets. On June 17, 1975, the steers were ear-tagged, pen-branded, weighed and assigned to one of the four pens on a rotational basis. All of the steers were given the regular treatment of grub and rednose control, and were given Lepto vaccinations prior to weighing.

Approximately 50% of the steers were Limousine-Hereford or Charolais-Hereford crosses, 15% Hereford-Angus cross, with the balance composed of Herefords or mixed crosses. Considerable variation was noted in the size of steers with starting weights varying from 500-950 pounds. The average initial weights were 667 pounds for the aspen group and 673 pounds for the control or hay-pellet group.

The rations for both groups were designed to contain approximately 11% protein on an air-dry basis. The guidelines for feeding each group were set up at the beginning of the feeding trial. Six rations for each group were planned so that, as the feeding period progressed, energy content in the ration would gradually increase. The initial ration (Ration 1) for the aspen group contained approximately 25% aspen pellets and the finishing ration (Ration 6) contained approximately 5% aspen pellets.

Because difficulty was experienced in getting the steers to consume the intended levels of aspen pellets, the rations were modified. Consequently, feed consumption shown later in the text will not correspond to that originally planned.

The original plan was to feed the steers on aspen bark the following: aspen bark pellets, corn silage, flaked corn, and protein supplement. As the feeding period progressed, the corn silage was to be gradually removed so that aspen pellets would serve as the only roughage. However, there was difficulty in getting the steers to consume the desired level of feed. This in turn, was affecting weight gains in the steers. The level of aspen bark was subsequently decreased and haylage (ensiled alfalfa hay) was added to the ration so that the roughage level in the ration would correspond to the control group. Corn silage was increased during July, and then dropped from the ration until November.

On June 30, 1975, two weeks after the trials started, the steers were "backing off" the rations shown in Table 2.

The difference of 2.3 pounds of dry matter intake per head between the two groups had an adverse effect on the gain of the steers fed aspen bark. Therefore, at this point, the recommendation was made to decrease the amount of aspen pellets in the

Table 2.--Feeding Ration as of June 30, 1975

	CONTROL			ASPEN		
	Daily Consump.	Dry matter1/ Consump.	TDN2/ Consump.	Daily Consump.	Dry matter1/ Consump.	TDN2/ Consump.
Corn	9.8	8.82	7.84	9.6	8.6	7.68
Protein	0	0	0	4.2	3.8	2.94
Hay pellets	9.8	8.82	4.9	0	0	0
Corn silage	7.68	2.3	1.55	10.0	3.0	2.0
Aspen pellets	0	0	0	2.5	2.2	1.25
TOTAL		19.94	14.29		17.6	13.87

1/ Dry matter values used: 90% D.M. for all feed except for corn silage which 30% D.M. was used.
2/ TDN values used: Corn = 80%; protein = 70%; hay and Aspen pellet = 50%; corn silage = 20% (on natural basis).

ration. On July 1, 1975, the aspen pellets were reduced to two pounds per head per day. After a couple of weeks, the feed consumption began to increase and consequently, the aspen pellet consumption increased back up to around 2.6 pounds per head daily. However, on a percentage basis, the level of aspen in the ration had not increased. About July 1, salt was mixed with aspen bark in the pellets. Then, during mid-August, the condition of the steers and the feed consumption records were examined. A decision was made to drastically reduce the quantity of aspen pellets in the ration.

On August 16, 1975, the aspen pellets were reduced to a level of less than one pound per head daily. Then, as the feed consumption increased, the consumption of aspen pellets increased to about 1.25 pounds and remained at this level for the remainder of the feeding trial.

The aspen pellets were estimated to be around 3% protein, but the composite figure for several batches of the pellets turned out to be 4.81% on an as-is basis or 5.0% on dry matter basis. The fiber content of the aspen pellets was 28.81% on natural basis or 30.3 % on dry matter basis.

RESULTS

The major findings of the feeding trial are reported in Table 3. The gains, feed efficiency and the slaughter-carcass data are all reported in the table. Feed cost comparisons are shown.

As noted in Table 3, the steers fed aspen bark pellets gained 4.15% less than the control steers (2.77 pounds daily gain versus 2.89 pounds). The lower gain must be attributable to the lower feed consumption encountered during the early part of the feeding period. Once the level of aspen in the ration was decreased, the total feed consumption increased. The steers that were fed aspen bark showed a marked increase in corn consumption during September, October, and November. This accounts for the larger figure shown for the average daily corn consumption (16.71 pounds flaked corn for aspen steers versus 15.88 pounds corn for control steers). Table 4 shows cost/lb. of feed and daily cost/head for feeding. Table 5 shows feed consumption by month.

A larger quantity of protein supplement was included in the ration for the steers fed aspen bark because of the low protein content in that feed. During the first 80 days, this commercial protein supplement (40% protein with 20% protein equivalence from urea) was fed to the aspen group. From September 7, 1975, a commercial protein supplement (32% protein with 19% protein equivalence from urea) was fed to both groups.

Since the steers on aspen pellets gained less and consumed more feed than the control steers, the control steers were 5.19% more efficient in their gains.

Trial steers consuming aspen bark ration

Table 3.--Aspen Feeding Trial Results (June 17, 1975 to November 23, 1975)

	Control	Aspen
Number of Steers	100	99[8]
Number of Days Fed[7]	149	147
Initial Weight, Lbs.	673	667
Final Weight, Lbs.	1100	1074
Total Gain, Lbs.	427	407
Average Daily Gain, Lbs.[9]	2.89	2.77
Average Daily Ration, Natural Basis, Lbs.:		
Grain (Flaked Corn)	15.88	16.71
Protein Supplement (Commercial)	0.91	2.43
Aspen Pellets	---	1.84
Hay Pellets (Alfalfa)	8.41	---
Corn Silage[1]	1.26	3.31
Alfalfa Haylage[2]	2.43	12.89
Air Dry Feed, Lbs.	26.55	27.13
Feed Required/Lb. Gain	9.25	9.79
Dressing Percent[3]	62.9	62.8
Liver Condemnation, %	29.7	12.24
USDA Carcass Grade[4]	15.0	14.9
% Choice	27.7	18.4
% Good	73.0	82.5
Fat Thickness, In.	0.58	0.57
Ribeye Area, Sq. In.	13.1	13.0
Kidney, Pelvic Fat, %	2.5	3.1
% Cutability[5]	50.16	50.09
Yield Grade[6]	2.95	2.97

[1] Corn Silage = 70% moisture

[2] Haylage - 60% moisture

[3] Cold carcass weight divided by delivered weight

[4] USDA Grade: 16 = Low Choice; 15 = High Good

[5] % of carcass weight in boneless, closely trimmed, retail cuts from round, loin, rib, and chuck.

[6] Yield grade 2 = 52.3 to 50.3% cutability

[7] Approximately half the steers were fed for 134 days, and the other half for 160 days

[8] Steer Number 147 was removed from this pen July 19, 1975

[9] Statistically significant as 5% level

Trial steers in feedlot, one week before first shipment

Table 4.--Feed Cost (1975)

	1975[1]/ Cost/Lb.	CONTROL Daily Cost/Head	ASPEN Daily Cost/Head
Average Daily Ration, Natural Basis, Lbs.:			
Grain (Flaked Corn)	$0.060	$0.95	$1.00
Protein Supplement (Commercial)	0.080	0.07	0.19
Aspen Pellets	0.017	---	0.03
Hay Pellets (Alfalfa)	0.042	0.35	---
Corn Silage	0.011	0.01	0.04
Alfalfa Haylage	0.015	0.04	0.19
TOTAL (Natural Basis)		$1.42	$1.45

[1]/Costs for flaked corn, protein supplement, corn silage, and alfalfa haylage from Collins Farms; costs for aspen & hay pellets from USFS calculations.

Table 5.--Feed Consumptions by Month (as fed basis)

STEERS FED ASPEN BARK

	Protein Supplement	Flaked Corn	Corn Silage	Haylage	Aspen Bark Pellets	Salt
6/17/75- 6/30/75	5,680	9,300	14,550	--	5,330	22
7/01/75- 7/31/75	8,880	40,390	33,480	37,440	7,910	109
8/01/75- 8/31/75	8,095	49,870	---	67,200	6,110	48
9/01/75- 9/30/75	5,220	53,740	---	40,750	3,000	--
10/01/75-10/31/75	5,200	63,670	---	29,580	3,350	--
11/01/75-11/23/75	2,300	26,240	100	12,580	1,360	--
TOTAL	35,375	243,210	48,130	187,550	27,060	179

CONTROL STEERS

	Protein Supplement	Flaked Corn	Corn Silage	Haylage	Aspen Bark Pellets	Salt
6/17/75- 6/30/75	---	13,190	10,220	---	13,260	30
7/01/75- 7/31/75	---	42,900	8,440	10,160	29,520	58
8/01/75- 8/31/75	---	48,840	---	20,590	25,360	20
9/01/75- 9/30/75	4,700	50,840	---	5,200	21,560	--
10/01/75-10/31/75	6,070	54,660	---	---	24,260	--
11/01/75-11/23/75	2,760	24,620	---	---	10,570	--
TOTAL	13,530	235,050	18,660	35,950	124,530	108

The steers in the feeding trial were shipped to Denver on three different dates. The first group, consisting of 44 control and 45 steers fed aspen bark, were shipped on October 29, 1975. Since a high percentage of the steers did not make the choice grade, it was decided to delay the shipment on the balance of them. Four weeks later, the balance of the steers were slaughtered. Based upon the records, the extra four weeks of feeding didn't improve the carcass grades: 22% of the steers fed aspen bark were graded choice in the first shipment, and 15% graded choice in the second shipment. In comparison, 29% and 23% of the control steers were graded choice in the first and second shipments, respectively.

It is difficult to determine why a larger percentage of the steers in either group did not grade choice. Degree of marbling is the major factor which determines the quality grade (to grade choice, good, etc.). Available data indicates that yearling steers fed either for 130 days or over or with grain

consumption exceeding 2,200 pounds per head should grade 70% choice or better. In both the group fed aspen bark and the control group, the grain consumption exceeded this level (actual corn consumption was 2,432 pounds for the group fed aspen bark and 2,351 for the control steers).

In summary, the results of the trials were as follows:

- Liver condemnation was lower in the steers fed aspen bark. Condemnation percentages were identical to a recent Canadian study.

- Sickness was noted in only one of the steers fed aspen bark.

- Gain was 4.15% less in the aspen bark fed steers, and was probably due to lower feed consumption during the early part of the feeding period.

- Even though larger amounts of corn silage and alfalfa haylage were fed than planned, the daily feed cost per head for the steers fed aspen bark was only 3¢ higher than the control group.

- Choice carcass grade was 9.3% lower in the aspen bark group than in the control group.

- Carcass data, other than liver condemnation, gain, and grade were very similar for the two groups.

The following problem summary should help facilitate planning of possible future feeding trials. Problems were:

- Delay in planned delivery of aspen logs to the mill due to wet spring logging conditions.

- Bark loss (about 25% of the total) between the stump and the mill due to bark slippage on logs cut in the spring.

- Need for bucking tree-length aspen into shorter lengths to accomodate the ring debarker at Silver Tip Studs due to the high amount of crook and sweep in the aspen.

- Lack of adequate available bark drying facilities at Montrose

- Difficulty in hammermilling bark above 15% moisture content. This was attempted once.

- Steers "backing off" the aspen bark pellet ration, which resulted in modifying the ration to maximize weight gain on these steers

- Low % of choice grade in both the control and the aspen bark steers.

- Because of ration changes, the proportion of grain to roughage between the two rations are not comparable. Consequently, the differences in weight gain of the steers, feed consumption, carcass grades and all the other parameters compared, cannot necessarily be attributed to the aspen bark included in the ration.

CONCLUSIONS

Further research in feeding aspen bark to steers is needed to help resolve the question of palatability and other problems encountered in this pilot test. It is evident that some other ingredient, such as dehydrated hay, should be mixed in with the aspen bark before pelleting.

Wildlife (deer, moose, elk, antelope, mountain sheep) feeding tests are being conducted with aspen bark by Wyoming Game and Fish near Wheatland, Wyoming. A report will be written upon completion of the trials. Further investigative work should be done in this area, if indicated from the Wheatland trials.

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ACKNOWLEDGEMENTS

Other people who participated in conducting these trials and writing this report are:

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- Dr. Eugene Wengert, Extension Specialist, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

- Jim Free, District Ranger, USDA-Forest Service, Canon City, Colorado.

- Wendell Turner, Range Conservationist, USDA-Forest Service, Montrose, Colorado.

- John Minow, Deputy Director, Range and Wildlife Management, USDA-Forest Service, Denver, Colorado.

Aspen Veneer And Plywood[1]

Harry E. Troxell[2]

Abstract.--The aspen resource in the Rocky Mountain region never has been utilized to its potential. The wood properties of this fast-growing and short-lived species are reviewed as a source of veneer. Aspen is a low density hardwood species with specific gravity falling within the range of .30-.44. The species properties are suitable for veneer with the typical veneer logs being about 10-14 inches in diameter. The creamy-white sapwood comprises the major protion of the cross-sectional area of the stems. There is a tendency for the veneer surfaces to be fuzzy due to tension wood. Veneer drying can be accomplished with a moderate degree of success. Some aspen veneer has an attractive figure and can be selected for decorative panels. It makes good core and crossband material. It is a preferred container wood and suitable for stamped veneer items. The light color, facility of cutting, ease of gluing and nailing and uniform texture are assets which warrant its consideration for use as veneer species.

A program which considers the possible uses of aspen in the Rocky Mountain region should not overlook veneer and plywood. The aspen resource, as pointed out by previous speakers, has never been utilized to its potential. The "coming age of wood" does not mean an easy task lies ahead for utilizing previously little-used species but rather opportunities are there to challenge the insatiated imagination of our industry to couple the technologies of growing, harvesting, processing and marketing a species that has technical properties desirable for the needs of our society. Continued effort and education of the general public is necessary to use efficiently and effectively the aspen resource. We must learn to adjust to a changing resource base. We as educators, researchers, and industrial users of the wood resource must create the kind of programs and services designed to bring about better utilization of aspen.

1/Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Fort Collins, Colorado, September 8-9, 1976.

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3/Refers to Literature Cited.

In order to use Rocky Mountain aspen for veneer and plywood it is essential to know the volume, size and form of the trees as well as the physical and mechanical properties. Lutz (3)[3] says the final judgment of a veneer wood is best made on the basis veneer cutting and drying evaluations made from representative logs.

The wood and log characteristics that affect the quality of aspen veneer are the uniformity at which the veneer can be cut, the surface roughness and the freedom from buckling or wrinkling when green as well as when dry. The significant characteristics of making face veneers is the ability to control figure, color and depth of checks. Natural defects of knots, splits and presence of decay and stains are even more limiting to face veneers. For core and crossband material aspen has properties that make it suitable. The veneer and plywood product standards currently being used in the United States recognize aspen for hardwood and decorative plywood (9) and for construction and industrial plywood (10).

In the hardwood and decorative plywood standard the wood species are grouped on the basis of specific gravity and aspen is included with those species whose specific gravity is less than 0.42. In the construction and industrial plywood standard it is found in

the Group IV woods. The grouping in this standard is based on strength, specifically, modulus of rupture, modulus of elasticity, compression parallel-to-the grain compression perpendicular-to-the grain and shear. Group I represents the strongest and stiffest species. To meet Group I use requirement, aspen for construction and industrial plywood for a 32-inch sheathing and a 16-inch floor spacing use would have to be one-quarter-inch thicker.

The physical properties of aspen of interest to veneer producers are specific gravity, moisture content, permeability, shrinkage, extraneous, cell contents, figure, odor, cell size, type and distribution. Most Rocky Mountain aspen falls within a range of specific gravity of 0.30-0.44.

A comprehensive study establishing the specific gravity for western aspen has never been conducted. Wengert (7) reported from limited sampling from sites classes 1 and 2 the following specific gravities:

Source	S.G.*	S.G.**
Sapwood	0.384	.43
Heartwood	0.387	.43

* green volume, oven-dry weight

** oven-dry volume and weight

The above values are consistently higher than those reported by Markwardt and Wilson (5) for the Rocky Mountain aspen. The earlier information had been determined from six New Mexico trees displaying a growth rate of 7.3 rings per inch, nearly 3 times the average observed by Wengert (7). It appears that the suggested range of specific gravity perhaps represents the best information available.

The moisture content of aspen, like many species varies drastically depending upon the season of the year. Wengert (7) states that typical average values for the Rocky Mountains to be 74 percent for the heartwood, 91 percent for the sapwood, and 96 percent moisture content based on the oven-dry weight of the wood. Log storage in the woods results in very little loss of moisture if the bark remains intact. Some checking due to drying should be expected for logs when the ends are exposed to direct sunlight and wind.

Data for aspen indicates comparative low shrinkage average shrinkage values: volumetrically, 11.5 percent, radially, 3.5 percent and tangentially, 6.7 percent in drying from green to oven dry conditions. Normally tangential shrinkage is about twice that observed radially. Longitudinally shrinkage of wood normally is very slight and generally ignored. Aspen frequently has tension wood which may result in abnormal longitudinal shrinkage. This can cause noticeable warping of veneer.

The typical Rocky Mountain aspen stands will produce logs from 10-18 inches in diameter. They have only a slight taper, some crook, some shake and about one-fourth to one-third of the cross sectional area will be heartwood (1). Aspen heartwood, compared to the sapwood, is slightly darker in color and the permeability is much less. Wengert (6) reports the heartwood vessels are heavily occluded with tyloses.

The presence of decay, tension wood, knot patterns, wetwood and stains in the wood does limit the veneer potential of the logs. Lutz (4) in a northern Minnesota veneer yield study found 43 percent of aspen veneer to be of poor quality; 20 percent possessing small, tight knots and other defects and that about 37 percent of the veneer was free from defects. It is reasonable to assume a similar relationship could be obtained from Rocky Mountain aspen.

The volume yields for Lake States aspen were made by Bulgrin et al (2) at the U. S. Forest Products Laboratory, Madison, Wisconsin. Recently a 50-log exploratory study of Rocky Mountain aspen was conducted. The results of exploratory study were similar to those reported in the 1966 research paper as follows:

Bolt diameter (inches)	Veneer yield (sq.ft.--3/8-inch basis	Volume recovery factor
8	25.0	2.5
9	32.4	1.6
10	41.6	1.4
11	56.1	1.9
12	76.0	1.9
13	95.9	1.9
14	108.3	1.8
15	108.0	1.5
16	118.8	1.5

Because of the relatively low density of the wood, the presence of tension wood and wetwood, some difficulty is experienced in cutting veneer which is free from having fuzzy surface. Veneer cutting techniques of cooling veneer bolts to 5°C (40°F) prior to cutting, or using an extra hard knife, or run cold water between the knife and pressure bar are outlined as remedies by Lutz (4). Due to the presence of decay and wetwood some difficulty is experienced with the twisting out of the chucks in the lath.

Aspen veneer requires a slightly longer time to dry the veneer than most hardwood species due to the high original moisture content. The presence of tension wood does cause some buckling of veneer. Wetwood in aspen subject it to checking and collapse during drying. Aspen veneer which is free from tension wood and wetwood will dry flat.

An overview of the relative suitability of aspen for various uses would indicate that it is best suited for decorative plywood paneling, inner plies for plywood, container veneer and plywood and high valued stamped veneer products. The use of aspen for structural plywood has some limitations: namely, the comparative strength properties, the log sizes, the veneer yield and the cost of producing plywood.

SUMMARY

Aspen has many characteristics which make it desirable from veneer and plywood production. The relative low density and soft texture of the wood, the ease of machining, the stability of the wood, the facility of gluing, freeness from odor and the pleasant appearance of wood surface are all features which focus attention toward aspen veneer and plywood products. Important limitations to be considered in the use of aspen are the small logs, relatively low yield, the cost of harvesting and processing and the comparative lower strength properties of aspen when compared to other veneer species.

In spite of the many factors, both technical and economical, that need to be answered in order to develop an aspen veneer and plywood production in the Rocky Mountain region, sufficient evidence exist that full utilization program for the aspen resource should be directed to veneer and plywood. Successful harvesting and processing methods have been developed for other little-used species that have similar limitations as aspen. We need to now point attention to aspen as a veneer species.

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Perspective On Particleboards From *Populus* spp.[1]

Robert L. Geimer[2]

Populus species particleboards have a high compression ratio resulting in high bending strength. Their low-porosity edges, advantageous in furniture manufacture, dictate close moisture content control in production.

Aspen roundwood is the primary raw material for composition structural sheathing. Populus utilization will likely increase as material sources expand and as new products develop.

Aspen (Populus spp.) is considered to be an excellent raw material for manufacturing particleboard. Some characteristics which favor its use in particleboard are a relatively small springwood to summerwood density gradient which permits quality flaking and uniform drying, the lack of resinous substances which enhances good adhesive bonding, and the light color which is esthetically pleasing to many users.

Whereas aspen is only one of several underused hardwoods available in this area, its low density characteristic makes it more desirable for particleboard furnish than a denser species such as birch. An important difference is in the bending strength properties. An aspen particleboard averages 34 percent stronger in bending than a birch board at several levels of resin content (fig. 1).[3] The same trend is observed when other manufacturing variables which affect bending strength are varied. An aspen board is approximately 1400 psi stronger in bending than a similar birch board at various flake thicknesses and board densities (figs. 2 and 3, respectively).

Aspen's strength advantage is attributed to its high compression ratio, i.e., board density to species density. Because aspen is lighter in weight than birch, more flakes (of the same thickness) are needed to obtain the same weight board. The aspen flakes are pressed to more intimate contact than are birch flakes and consequently better adhesion occurs. The strength-compression ratio relationship is well illustrated in other work done at Forest Products Laboratory (Vital et al. 1974) where species of different densities were mixed in varying amounts and boards were made at constant compression ratios (fig. 4).

Besides increasing strength, the high compression ratio of a low density species also results in a board with a low porosity or "tight" edge which is of considerable importance in the furniture trade. The same condition, however, restricts steam release during pressing of aspen boards causing "blows" to occur. Moisture content must, therefore, be closely controlled in the manufacturing process, especially when large flakes are used as in wafer boards. Lower mat moisture content, as well as good resin dispersion, is achieved by using powdered resins in the production of aspen wafer boards.

Related work at the Laboratory during the past few years verifies the excellent performance of aspen in obtaining a board which is strong in bending, compression, and tension parallel to the grain, and shows that aspen particleboard in comparison to the higher density hardwoods tends

1/ Paper presented at the symposium "Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains," Ft. Collins, Colorado, Sept. 8-9, 1976.

2/ Geimer is a research Forest Products Technologist at USDA Forest Service Forest Products Laboratory. The Laboratory is maintained at Madison, Wis., in cooperation with the University of Wisconsin.

3/ Haskell, H., Heebink, B. G. How the physical properties of flake-type particleboards are affected by the species of wood, flake dimension, binder content, and density. Unpublished report. Forest Products Laboratory, Madison, Wis.

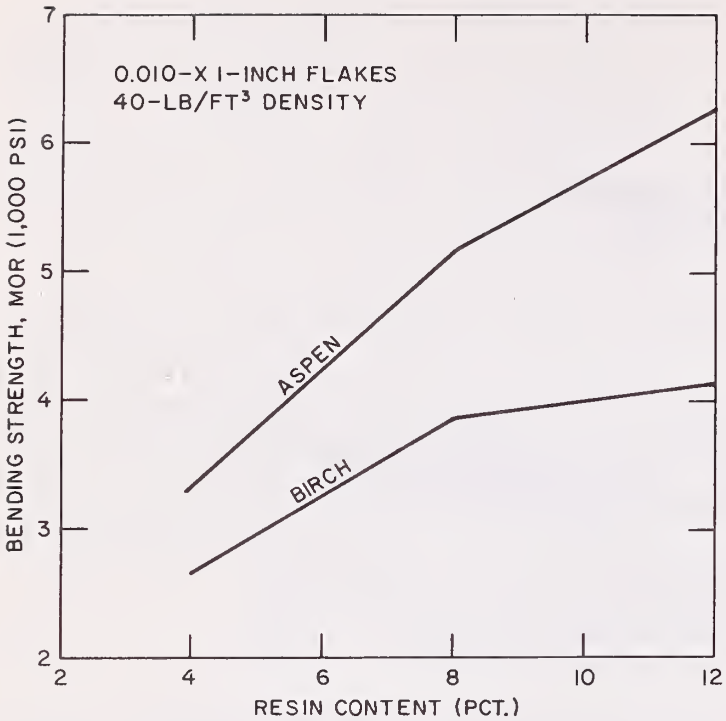

Figure 1.--Bending strength vs. resin content.

to have less linear expansion, but more thickness swelling and a lower internal bond strength. As shown in figures 1, 2, and 3 the board properties can be changed by varying construction details. A variety of layered boards has been made in laboratories to obtain board properties optimum for applications such as furniture corestock, mobile home flooring, or exterior sheathing.

Exterior sheathing is the market in which most of the recently developed aspen wafer boards are finding an outlet. In some areas, wafer board is being marketed as a decorative panel at a substantially higher price. At the present time, there are six plants in Canada and one plant in the United States using aspen to manufacture wafer board. The rapid expansion of the wafer board industry in Canada has created a production capacity almost double the consumption rate. Efforts are currently being made to market the Canadian product in the United States.

Use of aspen is not peculiar to wafer board mills (table 1). The Westvaco plant in Tyrone, Pa., used this species for interior-type boards, until the local supply was exhausted. Columbia Forest Products, located in Sprague, Manitoba, used aspen as its raw material until it burned down a few years ago. Several other Canadian mills use aspen in their furnish. In the Lake States, three mills are currently producing all or partially aspen boards. Publishers Paper Company in Virginia, Minn., produces an all-aspen, phenolic-impregnated paper-overlaid board for exterior siding. The other two mills, Weyerhaeuser in Wisconsin and U. S. Plywood-Champion Papers, Inc., in Michigan, market mainly interior-

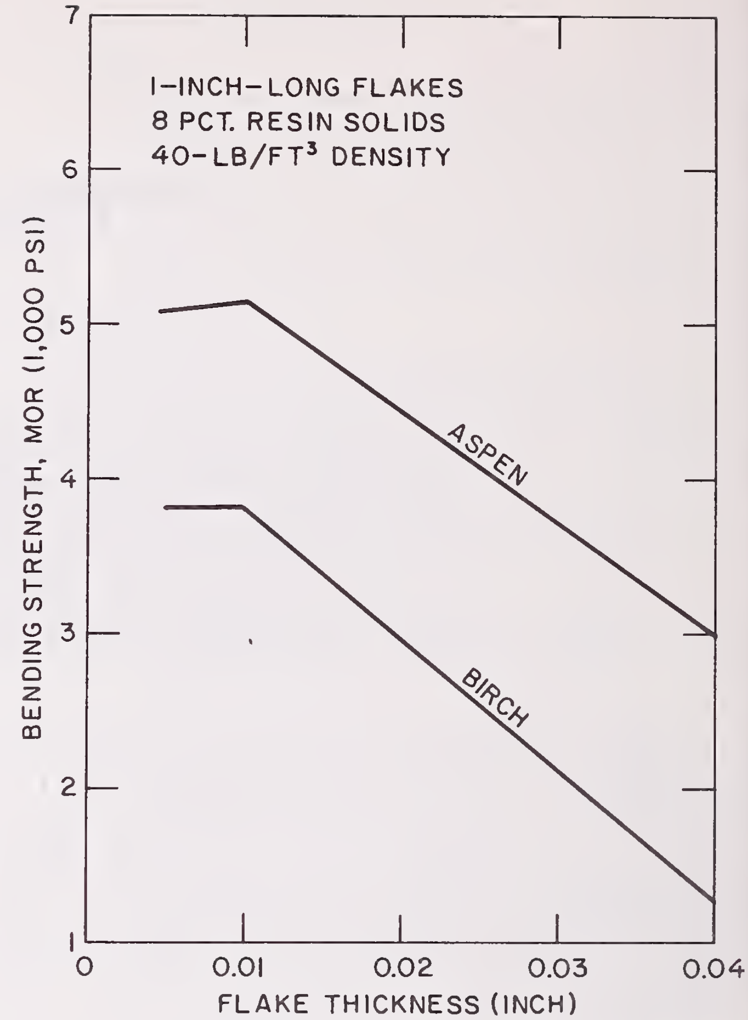

Figure 2.--Bending strength vs. flake thickness.

type boards to the furniture, case goods, and mobile home industries.

It is interesting to note that while both of these mills were originally designed to use roundwood, economics have justified product and process changes necessary to utilize mill and forest residues.

The shift to using mill waste led to plant design changes in receiving and processing equipment suitable for handling wood in the bulk form of chips. Recent advances made in chipping of whole trees in the forests has created a new source of raw material which appears to be cheaper and which has, in some cases, doubled the per-acre yield. The use of whole-tree chips has not been without problems. Dirt and grit have dramatically shortened flaker knife and saw blade life. Reduced flake length, increased fines, and a higher percentage of bark tend to reduce strength and increase glue consumption, while less control of species mix causes variations in production control. Despite these disadvantages, economics dictate that whole-tree chipping will provide an ever-increasing portion of the raw material used by particleboard mills.

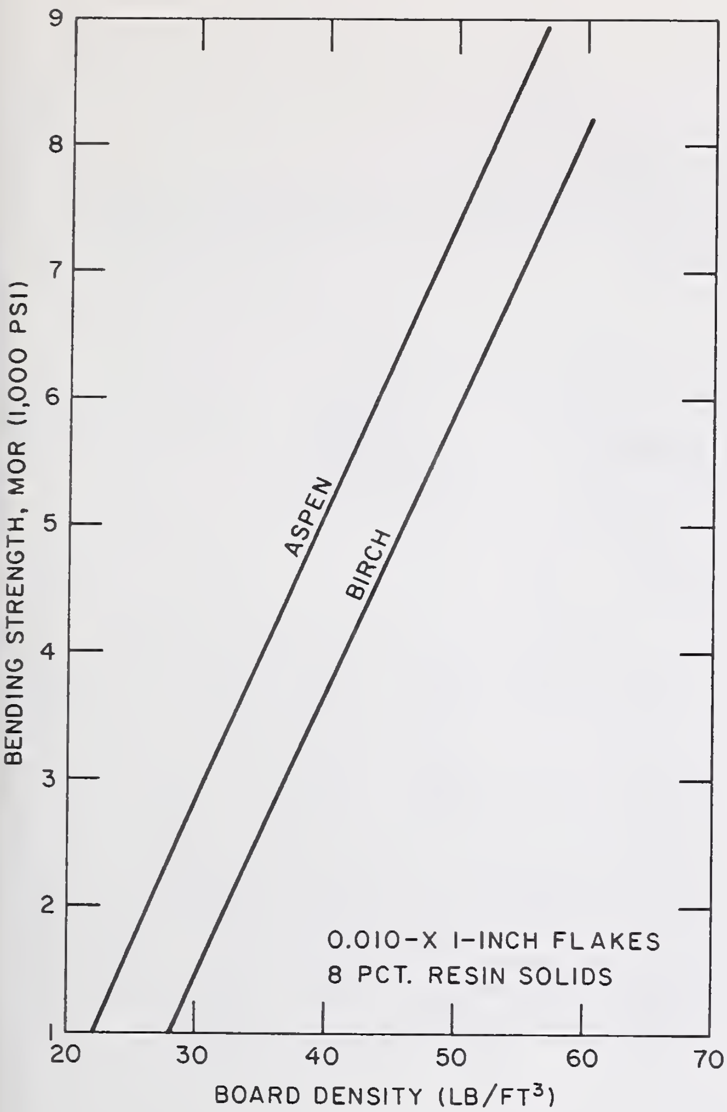

Figure 3.--Bending strength vs. board density.

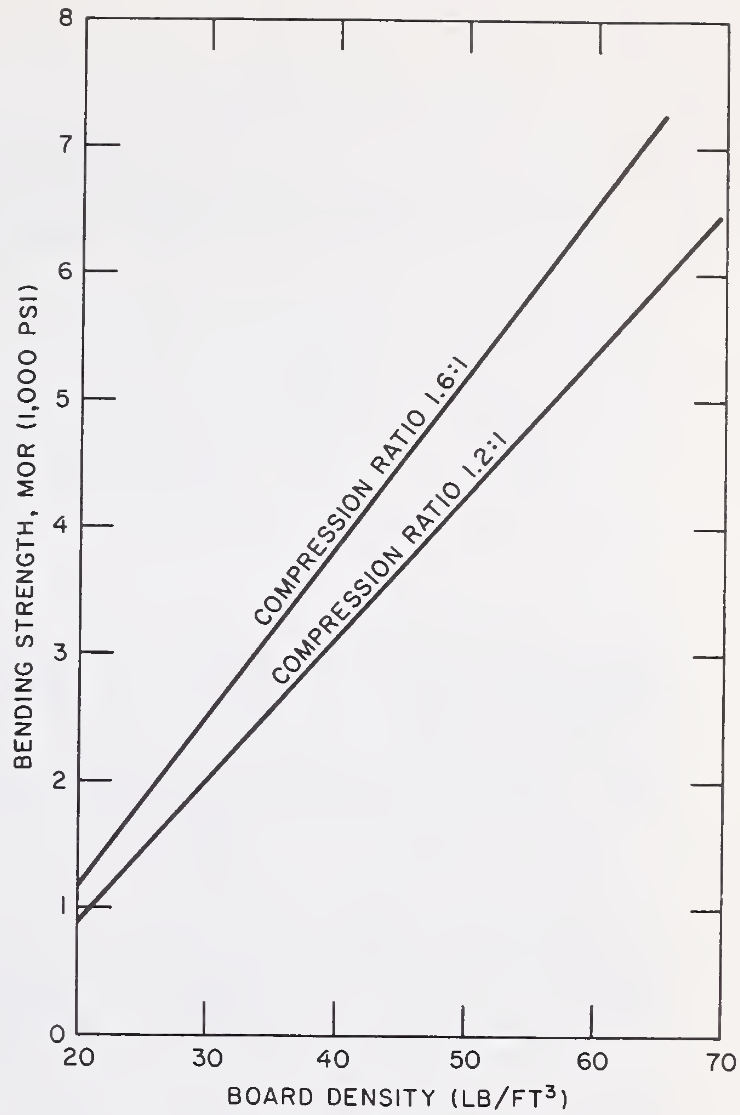

Figure 4.--Bending strength as a function of board density and compression ratio.

Whole-tree chips currently produced are of a size suitable for making interior type boards. Increasing the chip size (to "maxi-chips" or "fingerlings") (Heebink 1971) permits cutting of large flakes which can be used in the manufacture of exterior structural flakeboards. The technique is currently being used commercially to cut large softwood chips into flakes which are, in turn, made into a directionally oriented flakeboard used as the core layer of a composite particle-veneer board. The technique has also been used at Forest Products Laboratory for studies on use of 3- to 6-year-old hybrid poplar clones as raw material for particleboard. Although this material contained over 30 percent bark, boards with excellent strength qualities were obtained (table 1).

The need for additional sources of raw material for current production is becoming more urgent as present supplies of mill waste are reduced through greater efficiency or are captured by competing particleboard mills, papermills, and energy-producing operations. As the quantity of high-grade lumber decreases in the face of rising demands, it is foreseeable that reconstituted products will be developed which are not mere substitutions for scarce items but rather will be designed for specific applications. Incorporation of such features as flake orientation, density control, and molded shapes will create high-value products. Development of these products will create a demand for an even greater raw materials supply from a versatile raw material--wood.

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Table 1.--Properties of Some Commercial and Laboratory Particleboards Made From Aspen

Producer	Species	Type	Density	MOR	Screw Holding Face	Screw Holding Edge	Linear Expansion	Internal Bond
			Lb/ft^3	1000 psi	Lb	Lb	Pct	Psi
Commercial								
Westvaco Corp.[1/] (Tyrone, Pa.)	Aspen	Flake	43	3400	250	250	0.20	85
U.S. Plywood-Champion[1/] Papers, Inc. (Gaylord, Mich.)	Aspen core, pine face	Flake	28-43	2650	340	240	.14	90
Weyerhaeuser Co.[1/] (Marshfield, Wis.)	Aspen	Flake	42	2800	275	230	.18	85
Columbia Forest Products, Ltd.[1/] (Sprague, Manitoba)	Aspen-pine	Homogeneous flake	25-45	2500	300	250	.25	80
Waferboard Corp.[2/] (Timmins, Ontario)	Aspen	Wafer	40	3200	--	--	.12	60
Laboratory								
U.S. Forest Products Laboratory[3/] (Madison, Wis.)	Hybrid aspen clones	Flake	40	4500	--	--	.14	85

1/ Refer to Wood and Wood Products (1970).
2/ From a speech by Helmut Moeltner, DHYM, Ltd., New Liskead, Ont., presented at the Eastern Canadian Section, Forest Products Research Society Meeting, Thunder Bay, Ont., Oct. 1975.
3/ Unpublished data by Geimer.

Problems And Opportunities Associated With Aspen Logging Systems[1]

Wendell H. Groff[2/]

The opportunities in equipment selection, production ranges and specialization available to a logger producing volume from a coniferous species in many cases are not available to an aspen logger. The logger must identify the limiting factors and design a logging system accordingly.

The subject of harvesting aspen has long been of interest to both industry and the land management agencies in the Rocky Mountain Area. Industry, in many cases virtually starved for raw material, has viewed aspen as an alternative to the usual coniferous species as a resource base. The land management agencies, aware of the pressing need for forest products and the restraining effect of ever increasing land use restrictions, have looked upon aspen as a means of increasing the productivity of available forest lands both through managing lands with production of aspen as the objective and through harvesting aspen with the objective of fostering production of the coniferous species.

While aspen does present an opportunity in terms of available wood fiber, the nature of the species combined with the present state of development of the industries utilizing aspen as a raw material place serious limitations upon one who must design an efficient logging system to harvest aspen. Please note that a "logging system" includes all aspects of the operation needed to move useable logs from the standing trees to the processing facility. We must consider access roads, contractual requirements and value of end product as well as such normal logging activities as felling, skidding and so forth.

From the outset, we must remember that the industry in the Rocky Mountain Area is logging aspen in relatively limited quantities at the present time. Aspen trees make logs and we know how to put logs into the mill. However, most aspen logging that I know of is being done with logging systems designed to produce logs from the coniferous species. In many cases this situation presents a problem in that the logging system in use is relatively inefficient when compared to one that could be designed to harvest aspen alone.

With the realization that present harvesting systems are successful to a degree in mind, the remainder of this report will present my own thoughts on why aspen is expensive to log in relation to the coniferous species and how these costs might be reduced.

Please note that I am speaking in very general terms. My comments are the result of my own experience with logging aspen in Southern Colorado and as such may not apply in other regions of the Rocky Mountain area.

General Remarks On Aspen As A Species

The aspen that I have worked with in the Rocky Mountains has really presented problems for the logger. It has been generally highly defective in terms of both visible and hidden rot, extremely crooked and of relatively small size. It seems that almost anything that can be wrong with a log will occur in aspen.

Aspen, when harvested for sawlogs, is commonly designated for cutting under one of three methods:

> When aspen occurs in a mixed stand it may be individually tree marked to be cut along with the coniferous species.
>
> In pure stands aspen may be designated for cutting on a diameter limit basis; a clear-cut if you will.

1/ Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, September 8-9, 1976.

2/ Southwest Forest Industries, South Fork, Colorado.

In a mixed stand with a managable but sub-merchantable coniferous understory the aspen may be designated for cutting by over-wood removal to foster growth of the understory.

These methods of harvest have been mentioned to illustrate the different logging situations that the logger must be prepared to contend with. The point is that it is almost impossible to design a logging system that will operate with equal efficiency in all three cases.

Aspects Of Aspen Logging That Increase Cost

Please note that my comments are directed toward the present situation in the Rocky Mountain area. Problems such as these occur when aspen is harvested by logging systems designed to produce volume from the coniferous species.

In my mind, the problems associated with logging aspen fall into three broad categories.

I. Nature Of The Species

As I mentioned before, just about anything that can be wrong with a log will probably occur in aspen. This condition causes the work that must be done to produce a usable log to increase. Since per unit logging costs are simply a function of the amount of man and machine cost necessary to produce usable logs this increased work must result in higher unit costs. The loggers simply must do more work per unit of production.

II. Contractual Restrictions

This topic is of prime interest to land managers who are working toward a management objective. To the logger, contractual requirements will either increase or reduce the amount of work that he must do. The per unit costs of logging production will vary almost in direct proportion to the variation of work required.

Among the contractual requirements that have the most drastic effect on logging costs are:

Protection of residual stands when working with individual tree mark or over-wood removal harvesting systems. Required logging practices that cause higher logging costs are such things as longer skid distances, pulling winch lines further, restricting log lengths, and restricting number of chokers. All of these restrictions may result in a loss in production per unit of time.

Slash treatment and/or disposal. The time that logging crews spend on slash treatment is time lost from actively producing logs. The more unproductive, in the sense of producing logs, work that they must do the more the per unit cost or production will rise.

High standard access roads may simply price the aspen logs involved out of the market.

Present utilization requirements specify that all sound wood that meets contractual specifications must be removed. This requirements causes real problems for a logger who must produce logs in eight foot multiples.

In my oninion, most of the problems that occur because of contractual restrictions are the result of applying a timber sale contract designed for a relatively high value species to low value aspen timber. In many cases the value of the end product to be derived from aspen logs will not cover the cost of producing those logs.

III. Economic Restrictions

The problems that fall under this category relate to the equipment choices available to the aspen logger and the opportunity for him to utilize that equipment in an efficient manner. Among the situations that are presently restricting the alternatives available to the logger are:

The mills currently utilizing aspen generally require a relatively small volume of wood annually. This means that a logger cannot really "gear up" for production unless he can work his men and equipment in other areas some of the time.

Relatively short operating seasons can further reduce the amount of time that the logging crews are working.

The value of aspen logs will many times not support high standard access roads. This can cause even more unproductive time as well as increased equipment repair cost.

These factors and others combine to effectively limit the time that an aspen logger actually spends producing logs. When one considers the effect of fixed cost and overhead it becomes apparent that per unit costs of production must go up unless the logger can produce at maximum efficiency.

Opportunities To Minimize The Cost Of Aspen Logging

Again let me emphasize that we are logging aspen right now. My comments are intended to present ways through which cost might be reduced in some situations. Careful planning of the logging operation, analysis of the logging situations to be encountered and cooperation between all organizations involved can at least minimize the effects of the restricting influences noted above.

Among the things that must be considered are:

I. Minimize The Effects Of The Nature Of The Species

Barring genetic development of a straight, sound aspen tree growing in a stand that produces 15,000 board feet per acre we can't do much about it.

II. Minimize The Effects Of Contractual Restrictions

The land managers must be aware of and practice the concept of "cost of log to mill". For the present time at least, it must be realized that perhaps the optimum level of land management cannot be achieved.

One possible way to reduce the cost of aspen logging would be to design a timber sale contract that recognizes the low value of the species and makes requirement of work accordingly. Within the value of the log, work and the associated cost elements should be allocated to the most desireable management objectives.

III. Minimize The Effects Of Economic Restrictions

The logger can do nothing about the nature of the species and very little about contractual restrictions. Further, short of moving to another area, he can do little if anything about the annual needs of the mill that he is working for.

However, through planning, analysis and initiative the logger can reduce his own logging cost by using the factors of production in the most efficient way available to him. Among the ways through which the logger can improve the efficiency of his operation are:

> If the mill needs only 2,000-3,000 MBF of aspen annually and there are no alternative means to utilize logging capacity then the logging system should be designed to produce only that amount. Among the things that should be considered are multi-use equipment such as self-loading log trucks, small crawler tractors, timber sales with primary access roads already in place and single species timber sales.
>
> The logger should attempt to develop a market for all species of logs. This would allow him to extend the logging season, select single-use and more efficient equipment such as feller-bunchers and grapple skidders, work on mixed species timber sales and produce a higher volume annually.
>
> All of these occurances would have a favorable effect on logging costs.

The essential point is that the logger must be aware of the restricting influences under which he must work and design a logging system to fit a given situation. The equipment choices, production ranges and specialization available under conventional logging systems designed to produce logs from the coniferous species may simply not be available to an aspen logger. Therefore, he must either reduce his cost through proper equipment selection or increase his volume produced through developing a market for other species.

In this report I have tried to summarize my thoughts on and experience with aspen logging. In my experience it has generally been more expensive to log aspen than one of the coniferous species. I have been asked why many times and it always comes down to volume produced per unit of time. It appears to me that conventional logging systems, from standing tree to processing facility, have not produced aspen logs as efficiently as they might be.

The opportunity to reduce the cost of logging aspen does exist in certain areas, particularly those where multi-species utilization is the common practice. In these areas careful planning in scheduling operations and init-

iative in developing a market for logs from the coniferous species will allow the logger to operate more efficiently.

In conclusion, three points should be made:

> The amount by which the "cost of log to mill" can be reduced through more efficient logging practices is relatively minor when compared to the reductions which can occur through elimination of certain contractual requirements.

> The most efficient logging systems require heavy capital investment. I personally cannot foresee a prudent logger making that investment unless he is assured of a long-term, high annual volume logging contract. At the present time it appears to me that these conditions cannot be met in the Rocky Mountain area.

> The most potential for development of an efficient aspen logging system lies first with the land management agencies and secondly with industry in that high volume facilities must be developed.

> Remember, the logger must have timber to log and he must have someplace to log it to.

Potential Utilization Of Aspen Residues In The Rocky Mountains[1]

David P. Lowery[2/]

Abstract.--The Rocky Mountain area has a good supply of aspen timber that is presently underutilized. The possibilities of utilizing logging residue and residue at primary manufacturing plants are explored. The pallet and container industries are potential markets for short board lengths. Short, clear, defect-free pieces of aspen can be used by furniture and toy manufacturers. Veneer waste also has value, as it can be processed into various consumer products.

INTRODUCTION

The aspen utilization problems of today in the Rocky Mountain area are essentially the same as those in Canada and are yesterday's problems in the Lake States. A symposium similar to this one was held in Edmonton, Alberta, in 1974 (Neilson and McBride 1974). The main problem for timber management in both Canada and the Rocky Mountain area is underutilization of the aspen resource and the main problem for the wood industry is how to utilize this species profitably.

Undoubtedly, the largest potential markets exist in primary manufacturing industries--pulp and paper, lumber, veneer and plywood, and particleboard. However, managers of primary manufacturing plants should be aware of other uses for aspen and thus be in a position to exploit these markets.

FOREST RESIDUES

For hardwoods such as aspen, forest residues are generally greater than for softwoods. This difference is due primarily to the crookedness of aspen stems, frequency of defects, the relatively small size of the mature tree, and the tree's branching habit. To profitably utilize this species, which is normally converted into relatively low-value items, more complete utilization is required than for many of the western softwoods. A vertically integrated processing plant that could produce a primary commodity and secondary products would be ideal. Unfortunately, the scattered nature of aspen stands in this area precludes the establishment of an all-aspen complex. The goal, then, should be to completely utilize the material and to process the material into the highest value products possible.

In conventional harvesting operations, logs are bucked at the felling site and the tops and branches are left at this location for future disposal. But changes in harvesting operations are being made. Whole-tree chipping is becoming common. In the Northeast, more than 40 whole-tree chipping machines are in operation. Recent studies (Einspahr and Harper 1976) of this new harvesting system indicate that immediate increases in per-acre yield greater than 100 percent are obtained for hardwoods and 20 to 40 percent increases result for softwoods. In other words, conventional logging leaves approximately 50 percent of the aspen tree in the forest as residue at the time 50 percent is removed for manufacture.

A modification of whole-tree chipping that is being used in some areas is to skid the complete tree to a landing and there cut the stem into saw logs. The tree crown is then chipped. Both whole-tree chipping and whole-tree skidding have the advantage of leaving the harvested area clean and esthetically pleasing. Most of the chips from these newer harvesting methods

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[1/] Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

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are suitable for use by the pulp and paper industry and the remainder can be used as fuel. The residue from conventional harvesting also has value as firewood.

FUEL POSSIBILITIES

The increasingly high cost of energy derived from fossil fuels is making the burning of wood in homes, resorts, and wood processing plants more feasible. It also is contributing to higher prices for fuelwood. Last winter in some areas of Utah, firewood was selling for about $60 per cord.

The fuel value of aspen is the same as that of practically all wood--approximately 8,000 Btu's per pound of dry wood. The specific gravity of aspen, 0.35, means that a greater amount of wood is required to weigh a pound in comparison with some of the denser eastern hardwoods such as oak, hickory, birch, and maple. The specific gravity of aspen is slightly greater than that of Engelmann spruce and slightly less than that of lodgepole pine. Two pounds of dry aspen wood has approximately the same heating value as a pound of coal, and about two cords of air-dry aspen is equivalent to a ton of coal.

Table 1 summarizes some of the pertinent values for aspen fuelwood:

Table 1.--Values important to use of wood species for fuel, for green and air-dry aspen (from Panshin and others 1950)

Weight/cord (pounds)		Heat content (million Btu)		Equivalent in tons of coal	
Green	Air-dry	Green	Air-dry	Green	Air-dry
3,440	2,160	10.3	12.5	0.47	0.57

The data in table 1 emphasize the importance of burning only well-seasoned or dry wood. If the wood is green or wet, it not only does not burn well, but a large amount of the heat generated in burning is used to evaporate the moisture present, so that combustion can continue. Storing and piling large quantities of wood also can pose problems.

USE AS PRODUCT STOCK

Residue at primary manufacturing plants also has considerable value. Short board lengths produced from crooked logs by the sawmill are often suitable for pallets, boxes, crates, and various small items. The characteristics of aspen that make it desirable for pallets and containers are its straightness of grain, ease of nailing, relatively light weight, and ease of stamping or branding.

The pallet industry is one of the fastest growing segments of the wood products industry. From practically nothing 20 years ago, the industry growth has been so great that today the National Pallet and Container Association estimates that one of every four trees felled in this country is used in pallet or box construction. The growth of the industry is expected to continue in future years.

There are several different types of pallets, classified according to their use. The two most common types are the standard or general purpose pallet used for storage and shipment of various items such as groceries and hardware and the bin or box pallet often used in orchards for transporting picked fruit. The standard pallet is 40 by 48 inches and contains approximately 26 board feet of lumber. In 1973, more than 200 million of these pallets were assembled (Reeves 1974). The bin pallet is the same size and of similar construction, but it has a plywood box attached to the pallet base. A much smaller number of bin pallets is required annually.

The general purpose pallet consists of stringers, leadboards, and centerboards. Stringers separate the top and bottom decks; leadboards are located on the edges and take most of the abuse from the forklift trucks; and centerboards provide the bearing surface that supports the load. The strength properties and other characteristics of aspen would ordinarily restrict its use to centerboards, but suitable designs and nailing patterns have been developed for all-aspen pallets (Heebink 1962; Stern 1974, 1975). All-aspen pallets are lighter and stiffer, but somewhat less rigid, than comparable all-oak pallets.

Preassembled pallets are bulky and costly to ship long distances, but pallet parts can be shipped relatively long distances for assembly by a dealer or user.

The same characteristics that make aspen suitable for pallet manufacture also make the species suitable for box and crate construction. Although many fruits and vegetables are now being shipped in fiberboard boxes and the use of box shook has been decreasing, the market is still sizable. The fruit-growing areas of the Southwest and Utah should be able to use aspen boxes. Mill managers considering such an outlet should study the situation carefully before embarking on the required investment or expansion program.

Aspen is also suitable for the manufacture of grain doors used in railroad cars during the shipment of wheat and other cereals. The wood is tasteless and odorless when dry and thus would not contaminate the cargo.

Other options are available for the sawmills that produce considerable quantities of aspen. Because aspen is a preferred species in the toy, furniture, and door industries, a "cut-up" operation may be a profitable venture. Such an operation would produce small, clear, defect-free pieces by ripping and crosscutting long and short boards to the desired sizes. Light weight and favorable fastening, machining, finishing, and gluing characteristics make aspen an ideal wood for various remanufacturing industries including those mentioned.

Toy manufacturers often use aspen for cutouts and play furniture. Furniture producers use aspen for parts and lumber core stock to be overlaid with decorative veneer. Glued-up aspen blanks are covered with plywood skins in the manufacture of solid-core doors and individual pieces may be used as spacers and the framing for hollow-core doors.

Aspen veneer waste at plywood mills can often be processed into small wood items such as tongue depressors, ice cream and popsicle sticks, swizzle sticks, toothpicks, sticks for cotton swabs, and matchsticks. The species is an excellent wood for these uses because of its light weight, light color, and lack of taste.

CONCLUSIONS

The potential for utilizing aspen boards and residue from primary manufacturing plants is tremendous. The desirable characteristics of the species make it suitable for many diverse uses.

Sawmill waste can be chipped to provide raw material for the pulp and paper and particleboard industry. However, this same residue can often be processed into stock for secondary manufacture. The only limitations on aspen use are the time, effort, and capital industry management is willing to devote to it.

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Recommendations On Processing And Storage Of Aspen Residue[1]

Andrew J. Baker[2]

Physical properties of residues of aspen wood and bark are summarized as are the processing requirements for marketing residues of the bark and wood for fuel, mulch, and poultry bedding at a primary manufacturing plant.

Important considerations in marketing and using residue of aspen wood and bark are processing methods and storage. The end-use requirements of the residue will determine processing needs and will also dictate storage conditions that can be tolerated. This report will summarize the physical properties of aspen wood and bark residue and the processing and storage requirements to market aspen wood and residue for fuel, mulch, and animal and poultry bedding at a primary manufacturing plant.

PROPERTIES OF ASPEN RESIDUE

For information on the physical properties of midwestern wood and bark residues and the processing required to make them acceptable for various markets, McGovern (1976)[3] collected samples of various residues and noted moisture content and bulk density before and after additional processing. Table 1 contains that information for aspen residue. The bark residue was in a form satisfactory only for fuel, but the sawdust and pulp chip screener fines were suitable for animal bedding in addition to fuel.

RESIDUE PROCESSING

To make bark acceptable as an animal bedding or mulch, McGovern processed bark in various ways (table 2). The barks referred to as having well-reduced particles were considered suitable for animal bedding or mulch. Hammermilled aspen bark was determined an excellent dairy cow bedding in tests at the University of Wisconsin-Madison. He noted, for bedding, a certain amount of fines in the fibrous bark aids in forming a bed, or mat, on concrete in an animal stall. The amount of bedding required per animal was greater with processed bark than with straw because of the differences in bulk density, but when considering its use, the total cost and availability must also be considered. For bedding, the bark should be in the green condition. When green, there is no dust problem and the bark forms a more stable mat than does straw. Aspen bark absorbs barn odors; this quality plus the others makes it a desirable animal bedding.

Aspen bark that is acceptable for animal bedding also is an acceptable mulch. Again the presence of a certain amount of fines is desirable, and the bark should be used in the green condition.

For poultry bedding, the bark must be dry to avoid health problems and the fines must be removed to avoid dust. Highly fibrous, bulky material is not desirable for poultry bedding.

STORAGE

Aspen bark has accumulated in piles at many Lake States mills. The piles constitute a hazard because the bark leaches and can burn. Little has been done to determine the effects of the leachate. Under certain circumstances,

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1/ Presented at Symposium Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colo., Sept. 8-9, 1976.

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3/ McGovern, J. N., C. E. Zehner, and J. B. Boyle. 1976. Investigations of Bark Residue for Livestock Bedding. For. Prod. J. (In press).

the leachate could be a problem because it will probably be colored with water-soluble extractives and may contain biological and thermal degradation products of wood and bark.

The storage of aspen pulp chips, aspen bark, and aspen whole-tree chips has been investigated at the Forest Products Laboratory; estimates at the Laboratory showed that outside stored aspen pulp chips lose about 1 percent weight per month due to biological degradation. In work at the Laboratory by Zoch on the storage of aspen bark, he constructed a 40- by 40- by 20-foot-high aspen bark pile in which thermocouples and weighed samples were placed. Preliminary results indicate the pile reached internal temperatures higher than 150° F. during the first 3 weeks of storage. The bark and the nylon mesh bags containing weighed samples within the pile in the high-temperature area were severely degraded after 1 year. Estimated weight loss during the year was 10 to 18 percent. Whole-tree chips are very susceptible to biological degradation. In experimental storage conditions at the Laboratory, rapid temperature increases have been observed. Where whole-tree chips are harvested and utilized, they usually are not allowed to accumulate. Users of whole-tree chips have reported that a pile can become warm or hot to the touch overnight.

The recommendation for storage of chips, if storage is necessary for more than 1 or 2 weeks, is the pile should not be built higher than about 20 feet. For bark storage, the pile should be only 10 to 15 feet high. Whole-tree chips intended for use as wood fiber should not be stored. Storage should usually not be on the ground because dirt will be picked up when the stored material is recovered. Even if chips are used as fuel, the soil and rocks can be a serious problem.

Table 1.--Properties of Aspen Residue 1/

Aspen Residue	Debarker	Processing Equipment	Moisture 2/	Bulk Density 3/	Applications
			Pct	Lb/ft^3	
Bark	Rosser, ring	None	33-47	7.9-16.4	Landfill
Bark	Rosser, ring	Hog, hammer-mill	45-47	9.1-10.4	Fuel, incinerate, landfill
Sawdust	--	Circular saw, edger	40-55	4.8-7.2	Bedding, fuel, products, incinerate, landfill
Pulp chip screener fines	--	Screen	51	8.6	Bedding, pulping, fuel, incinerate, landfill

1/ McGovern, J. N., C. E. Zehner, and J. B. Boyle. 1976. Investigations of Bark Residue for Livestock Bedding. For. Prod. J. (In press).

2/ Green basis.

3/ Ovendry weight per green volume.

Table 2.--Properties of Processed Aspen Barks[1]

Material	Processing	Fines Content	Bulk Density[2] Fines	Bulk Density[2] Coarse	Bulk Density[2] Aggregate	Particle Nature
		Pct		Lb/ft^3		
Aspen bark						
Ring debarked	Shredded-coarse	10.2	18.5	13.1	14.2	Coarse; unusable
Ring debarked	Shredded fine	23.8	16.8	10.1	10.6	Coarse; unusable
Shredded coarse	Hammermill-1[3]	45.3	24.8	12.3	15.2	Well reduced
Shredded coarse	Hammermill-2[3]	48.4	17.6	8.0	11.5	Well reduced
Ring debarked	Hammermill[4]	34.5	13.7	--	10.1	Well reduced
Shredded coarse	Disk refiner-atmospheric	66.4	20.2	3.4	8.6	Well reduced
Shredded coarse	Disk refiner-pressure	28.7	--	--	3.2	Fibrous
Commercial bedding						
Wood shavings	--	20.9	--	--	6.0	--
Oat straw	--	--	--	--	1.2	--

1/ McGovern J. N., C. E. Zehner, and J. B. Boyle. 1976. Investigations of Bark Residue for Livestock Bedding. For. Prod. J. (In press).
2/ Dry weight per green volume.
3/ Fixed hammer.
4/ Swing hammer.

Panel V.

Applying Research Information To Aspen Management Decisions

Moderator: John E. Bennett

Director,
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Applying Research Information To Aspen Management Decisions — — National Forests [1]

David L. Hessel [2]/

Abstract.--Aspen management on the National Forests of the Rocky Mountains has been at a very low level. Decisions on how this valuable resource is to be managed in the future to meet multiple use goals must be based on the best research information available. Land allocations made through the land use planning process (including NEPA) will define land management objectives for the aspen type. The choice of treatment of the aspen type depends upon the multiple-use objectives and local ecological conditions.

Past and Present Aspen Management

Colorado, as well as other states in the Rocky Mountains, is nationally known for its scenic beauty and recreation opportunities. The mountains and forests of these states draw millions of tourists to them each year. The aspen within these forests, of all the tree species in the Rocky Mountains, offers the greatest contrasts in scenic qualities. The green leaves mixed with white bark and then the fall colors of reds and golds combine to make forests of outstanding scenic beauty.

The aspen type on many National Forests also provides forage for livestock to produce red meat for the Nation. It is also key habitat for many species of wildlife.

In the past 70 plus years of National Forest management, the four million acres of aspen commercial forest lands have received little silvicultural treatment.

Also, in the past 50 years, fire has generally been controlled and kept out of the National Forests. With the past history of management, what is happening to many aspen stands in the Rocky Mountains?

Natural Succession

Aspen is being and will eventually be replaced in the Rocky Mountains by spruce and fir. Also, stands are over-mature and falling apart, losing fiber production.

Is this what is best for the National Forests in the Rocky Mountains to provide the American public its needs now and in the future?

Aspen Management Objectives

Aspen, as well as other resources of the National Forests, are managed to meet multiple use goals. Consideration must be given aspen timber values, other timber species values, wildlife habitat, recreation, range, esthetics, watershed and environment protection. It is important that the Forest Service keep in tune with the changing world in which we live. Making sure we are responsive and alert to the changing needs of a dynamic society requires a continuing evaluation of our management objectives and policies.

Some broad objectives that we must consider in managing aspen are:

1. To promote and achieve a pattern of natural resource use that will best meet the needs of people now and in the future.

2. To protect and improve the quality of air, water, soil, range, wildlife habitat, recreation and natural beauty.

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[1]/ Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Fort Collins, Colorado, Sept. 8-9, 1976.

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3. To generate forestry-based job opportunity to accelerate rural community growth.

4. To encourage the growth and development of forestry-based enterprises that readily respond to consumer's changing needs.

5. To develop and make available a firm scientific base for the advancement of forestry.

In order to meet these broad objectives, we must fit the aspen lands into the total resource and environmental picture. We have considered that change or modification is not strictly a timber production option. Moreover, a choice of action is not based on simple rules and it cannot be made for any single stand of timber in isolation from the surrounding land and human developments.

Multiple-use management explicitly recognizes the "jointness" of forestry in the sense that whatever we do to the forest environment is likely to affect the level and quality of more than one of the several "products" of the forest. These products are valued in several ways, not only in terms of dollars, but also in terms of less easily quantified values such as esthetics. Regardless of the values used, questions arise regarding the efficient allocation of forest and other resources to the production of these various products.

To be more specific, the principal potential uses of lands now occupied by aspen stands are:

Wildlife

The vegetation is used as a food and cover type. Some aspen provides big game winter range, but mostly is spring, summer, and fall range. The type is important for elk, deer, black bear, beaver, woodpeckers, the flammulated owl, and other species of nongame animals and birds. A key element in the management of the aspen type is the need for an appropriate mixture, in both area and distribution of aspen and conifer types, to assure a complete habitat for wildlife.

Watershed Protection

Aspen is valuable as protective watershed cover because of its rapid initial height growth characteristics and extensive lateral root system.

Recreation

Aspen adds to the recreation use in several ways. Maintenance of aspen ecosystem adds variety to the forest in terms of the diversity and number of species of wildlife available for viewing and studying. Large monocultures of ponderosa pine, lodgepole pine, and spruce are disrupted and vegetative variety is maintained or can be introduced.

Scenery

Aspen is an important tool to maintain or introduce color form and texture in landscape management in the Rocky Mountains. Color contrast, especially in the spring and autumn, is a highly valued resource of the Rocky Mountains.

Fire Management

Aspen has different burning properties than conifer stands. An appropriately designed pattern of aspen stands within larger areas of conifer stands could serve as a living fire break while serving other important management needs.

Grazing of Domestic Livestock

The understories (shrubs, grasses, and forbs) of aspen stands provide a great deal of forage used by cattle and sheep. Herbaceous production usually exceeds 1,000 pounds per acre on the most productive sites.

Wood and Fiber Production

Current utilization of aspen stands is 5-10 million board feet in Region 2. The potential is significant as aspen is suitable for core stock, studs, veneer, panels, lumber, pulp, excelsior, and possibly as a livestock and wildlife food supplement.

In light of the multiple-use concepts, and the broad management objectives and the specific potentials for the aspen type, land allocation decisions must be made through land-use planning including the NEPA process. The decision for aspen lands must be based on research information as is being assembled, presented, and discussed at this symposium.

Applying Research Information to

Aspen Management Decisions

As stated earlier in the session, the National Forests of the Rocky Mountains have over 4 million acres of commercial aspen forest lands that are capable of producing 20 cubic ft./acre/year. Land management decisions must be made on these acres. To accomplish the management objective, I see there are basically three options of treatment: regenerate aspen, allow natural conversion to another type, or artificially reforest. These choices depend on the multiple-use objective.

Therefore, the land manager has three harvest alternatives to consider in aspen management: clearcut, partial cut, or do nothing.

In the past it has been the response to these harvest alternatives in the Rocky Mountains to place the aspen in the unregulated components. Treatment by clearcutting or shelterwood led, in some instances, to suckering so profuse that it caused total site occupancy. This in turn eliminates the understory herbaceous vegetation critical to wildlife and domestic livestock needs.

In some instances in Region 2, suckering has not occurred, indicating that elements critical to the reproductive process have not been properly identified and handled. These elements must be identified and appropriate prescriptions developed to assure they are properly considered. The interaction of soil types and climatic conditions as they relate to the reproduction processes are not entirely defined.

The basic problem in Region 2 is that more information is needed on aspen management so that we can regulate aspen in our timber management plans, thus realizing its full potential.

Research studies and information as presented here at this symposium will help form the basis for the land manager to make decisions in the land-use planning process. It is these decisions that will result in the eventual establishment of potential yields from the aspen stands in the National Forest Timber Management Plans. I see this as a prerequisite in order to attract industry. Any industry must know its raw material supply; without a market for the wood fiber, little management will be accomplished.

Aspen in the Rocky Mountains can be elevated from its non-use status of recent years through advanced technology in its utilization as a wood fiber and development of a research base required to apply silvicultural techniques to achieve the desired management responses.

Guidelines For Aspen Management[1]

David R. Betters[2]/

Abstract.--The aspen of the Rocky Mountain Region represents a large, diverse resource. Currently there are no specific, detailed guidelines for its management. The development of management guidelines requires, in part, the identification of aspen's possible uses, stand-site characteristics to meet those uses and silvicultural prescriptions.

Guidelines, based on stand-site suitability, were developed and applied to a planning unit on the Routt National Forest of Colorado. The application, although limited in scope, did indicate the guidelines could be useful to aid in determining what aspen sites were most suitable for certain uses and what management alternatives might be applicable.

There are an estimated 3 million acres of aspen type forests in the Rocky Mountain Region. These forests have the potential to provide a wide range of possible uses. However, at the present time there are no specific, detailed guidelines for their management.

An approach to developing such guidelines should include:

1) Identifying and describing the uses for which aspen stands can be managed.
2) Identifying and describing the aspen stand characteristics most suitable to meet those uses.
3) Identifying and describing the possible management prescriptions given use and stand-site conditions.
4) Constructing a procedure to define aspen stand suitability for various uses.

USES

Aspen stands, when compared with most other forest types, provide an extremely wide range of possible uses. In the Central Rocky Mountains aspen timberlands serve for such significant uses as: wildlife habitat, domestic livestock range, raw material for wood production, watershed protection, water production, scenery and firebreaks.

These are certainly not minor but major values since aspen is very well suited for these uses. For example, in the case of wildlife habitat, aspen is the number one big game browse species and an important elk calving area (Jones 1974). Further it provides food and cover for a number of small wildlife species including grouse and the beaver (Beetle 1974).

Its value as domestic livestock range is exemplified by the fact that aspen typically produces six times the forage as adjacent conifer stands (Reynolds 1969). Most pure aspen stands have a heavy understory of various grasses and forbs which provide summer grazing for sheep and cattle.

As a wood raw material in the Central Rockies it is presently used to manufacture pallets, paneling and numerous specialty products (Wengert 1976).[3]/ Although its high moisture content, decay and small size cause problems the opportunities for expanding this type production along with its use for fence poles, livestock bedding and feed seem to be significant. In particular, livestock feed possibilities have been recently explored by a number of researchers (Milligan 1974).

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[1]/ Paper presented at the symposium Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Fort Collins, Colorado, Sept. 8-9, 1976.

[2]/ Assistant Professor, Department of Forest and Wood Sciences, Colorado State University, Fort Collins, Colorado.

[3]/ E. M. Wengert, Final report, aspen wood utilization in the Rocky Mountains, Work Unit FS-RM-4351, USDA Forest Service, Rocky Mountain Forest and Range Exp. Sta., Fort Collins, Colorado, 1976.

Aspen provides an important watershed protection role through its extensive lateral root system. Even one tree can provide considerable protection from erosion. It sprouts prolifically and quickly thus minimizing the time the site is bare (Croft and Monninger 1952). The fact that it often occurs on moist sites serves to further emphasize the significance of this use.

In comparison with other forest types aspen sites generate more water for runoff. Aspen typically has higher water yields than conifer stands in the snowpack zone (Dunford 1944, Hoff 1957). This occurs because aspen has less interception losses and a faster snowmelt period allowing more water for overland flow.

The beauty of aspen stands in the Fall is well known to those familiar with the Central Rockies. There is really no way to accurately measure the importance of this esthetic appeal. The stands intermingle with the darker conifers in a myriad of forms adding an especially appealing color and texture to the landscape.

Finally, aspen is an excellent firebreak in that it has little dead fuels and no ladder fuels to carry a fire to the crown (Fechner and Barrows 1976). In many cases, fires have been "herded" into aspen stands to control conflagations. Aspen clumps are particularly valuable where they mix with conifers and occur along roads, ridgetops or the bases of slopes where firelines might be constructed for fire control.

STAND-SITE CHARACTERISTICS

The stand-site conditions of Central Rocky Mountain aspen are very complex and diverse. It's been said that aspen has the most unique and variable characteristics of any North American tree species (Smith 1962). For example, it has a wide altitudinal range, has many different herbaceous understories, mixes with several coniferous species, grows in clones and has many stand structures ranging from all-aged to even-aged. Further, it occurs on several different soil types and various visual zones. This variety typifies the species and causes some management difficulties as well as opportunities.

The clones of aspen have different genetic characteristics which develop varying growth rates, sprouting characteristics, disease susceptibility and tree form. Because of clonal differences the same site conditions may have vastly different stand qualities. Whether there are only 2 or 3 races of clones or many is presently unknown. Obviously timber stand improvement work has major possibilities in the management of this resource.

These varying clonal characteristics, in part, contribute to the unpredictability of aspen sprouting. In some cases stands will deteriorate naturally and no sprouting will occur (Schier 1975). In other situations it sprouts under the deteriorating overstory (Jones and Harper 1976).[4] Cutting in certain areas generates prolific sprouting in others none at all. In some instances aspen will invade adjacent grassland, in others it maintains a static border. Of course, the inability to predict sprouting is a major management problem.

The insect and disease attacks in aspen are significant. In the Central Rockies Cytospotra, black and sooty bark cankers along with insect defoliators and borers cause considerable damage (Hinds 1964). Many older stands, after age 80, have appreciable amounts of defect and decay. Before age 80 most stands have a much lower percentage of rot (Davidson et al. 1959). This, of course, has a tremendous impact on the suitability of the wood for wood products and further affects the esthetic appeal of the resource.

The species mixes with conifers and many areas exhibit varying levels of succession. At first, the aspen acts as a "nurse crop" while the conifers become established in the understory. Then, as time goes on, the conifers and aspen mix as mature trees in the overstory until eventually the aspen is completely overtopped and dies (Weigle and Frothingham 1911). Where a conifer seed source exists this is the typical successional process.

Aspen also occurs with sagebrush, brush, grass and/or forbs. It can occur with understories of grass, grass/forbs, tall forbs or brush. In some cases these pure aspen stands deteriorate and convert to sagebrush, brush or grass--particularly at the lower elevations. In other areas, under certain conditions, it seems to perpetuate itself. These areas ought to remain aspen for some time and have been identified by several investigators as aspen climax zones (Baker 1925, Beetle 1974).

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[4]/ John R. Jones and Kimball T. Harper, Unpublished Draft Manuscript 1203.47 Aspen Ecology and Management in the Western United States.

Regarding aspen sites Reed (1971) states that the only common factor is that they occur on mineral soils. The better, more productive sites, however, are typically moister soils with a high organic matter content (Tew 1968). The best soils are loams, silty loams or clay loams derived from drifts that have a limey substrate (Brinkman and Roe 1975). Any appreciable amount of rock or gravel creates a poorer site as this interferes with the species lateral root development.

SILVICULTURAL PRESCRIPTIONS

There are many silvicultural prescriptions possible for aspen stands. These prescriptions may vary by use objectives and stand-site conditions.

The best harvesting method is to either clearcut or use a heavy selection with either tree length or shortwood logging (Heinselman 1966, Zasada 1972). Partial harvests are acceptable if at least 60 to 70% of the basal area is removed--otherwise the number and form of the sprouts is affected (Smith 1962). Cutting ought to be done in the best clones to perpetuate those genetically superior traits.

The best rotation age for the better sites has been found to be 70 or 80 years (Millar 1974). Thins can be scheduled between 5 to 15 years of age. It's best to wait at least 5 years as natural competition will remove several of the sprouts (Jones 1976). At the other extreme 15 years is a limit in that cutting done later might stimulate new suckers as the sprouts have developed their own root systems.

Chemical treatments can be used to thin stands. Chemicals including sodium arsenite, 2-4-5T and 2-4D are effective (Johnston 1969). If chemicals or cutting is not feasible heavy grazing by sheep two or three years following cutting will also eliminate sprouts (Baker 1925).

Where a conifer understory exists and conifers are desired care must be taken to insure the conifer understory is well established before any cutting of the aspen takes place. Otherwise the chances are that the site will be taken over by aspen for some time (Jones 1974). Even scattered aspen within a conifer stand can develop significant amounts of sprouting if the forest floor is opened up to sunlight.

Prescribed burns can also be used to stimulate sprouting and/or remove an aspen overstory. However it should be noted that only under certain conditions will the fire resistant aspen carry a fire.

These prescriptions typically benefit many uses in providing increased wildlife browse, livestock forage and water runoff. The treatments also help perpetuate the aspen for scenic purposes and watershed-firebreak protection.

GUIDELINES

In order to develop a management approach the variety of stand-site conditions must be depicted in a classification scheme. As a first step the most important characteristics concerning the conditions need to be identified for the aspen resource. These characteristics should be those considered to be necessary to determine the area's suitability for aspen's large number of uses. They should be those characteristics easily identifiable in the field and be available in present inventories. Further, they ought to include criterion, such as visual zoning, which is not a vegetative descriptor but is an important factor to consider in making management decisions. The criteria should be capable of describing the large varability in the resource. Although others might be considered a set of characteristics could include:

1) soil stability
2) aspen vegetative type (i.e. aspen/grass, etc.)
3) timber site quality
4) scenic rating (partial retention, etc.)
5) stand structure

The suitability of an aspen site can be determined using these characteristics. A procedure to link site condition to its most suitable uses would involve two steps. First, the characteristics, 1 through 5, must be ranked as to their importance for each use. For example, what characteristics are most important for determining an aspen site's suitability for timber use? Second, given a particular use, the favorable and unfavorable conditions for each characteristic must be identified. Table 1 illustrates this approach using timber production as an example.

This same procedure might be used to determine the characteristic importance rankings and condition favorability for the number of different uses of aspen. These rankings and conditions may be quite distinct for each

Table 1.--An example of determining characteristic importance and condition favorability for timber use.

	Aspen Characteristic Importance Ranking	Conditions of Favorability: Favorable	Conditions of Favorability: Less Favorable
#1	Timber Site Quality	I-II	III-V 1/
#2	Soil Stability	Stable; Mod. Stable	Unstable 2/
#3	Scenic Rating	Mod./Max. Mod.	PR-Ret. 3/
#4	Vegetative Type	Pure aspen w/ herbaceous understory	Aspen mixed with conifer 4/
#5	Stand Structure	Undiff.	5/

1/ Baker (1925) aspen site index.
2/ As defined in unit land use plans.
3/ As defined in USDA USFS Handbook #434.
4/ As defined in unit land use plans.
5/ Undifferentiated--meaning any condition is equally favorable.

use. For example, timber site quality may be very important in determining timber suitability (#1) but be of little consequence for forage rankings (#4). A timber quality index of I or II might be a favorable condition for timber but any index might be equally favorable for forage. These type differences exist for all uses.

By numerically weighting each characteristic in order of importance, individual use ratings can be developed for an aspen site. For example, using this approach an aspen site having moderately stable soils, a timber site quality of I, an aspen/grass vegetative type and a partial retention scenic zoning was rated 8 for timber, 8 for forage and 10 for scenery (out of a possible 10). Other uses were rated much lower. Thus this site is most suitable for timber, forage and scenery uses.

APPLICATION

This approach was developed and applied in a summer study of the aspen resource on the Routt National Forest in Colorado (Betters 1976). In forming the importance rankings and conditions for favorability various forest managers were consulted for their opinions. What finally developed was a set of keys similar to taxonomic keys which could be easily used to determine a site's suitability for various uses. As a final step a set of management alternatives was then offered given an area's overall suitability rankings.

In field testing the guidelines it was obvious that numerous aspen sites were very suitable for many uses. Several areas on the Routt National Forest were highly suited for timber-forage-scenery uses. Many other sites were very suitable for watershed protection, scenery and firebreaks. The prescriptions for each use are essentially the same. These numerous complementary, noncompetitive relationships indicate significant possibilities for multiple use management.

This does have major importance in the development of an aspen management program. For instance, prescriptions may not be justified solely on the basis of timber value but on multi-use sites, considering all uses, the total benefits may far outweigh the costs. Wood utilization markets now plague the development of a management program. However, if all the uses are considered, there may be ample justification for prescriptions through joint funding means. The timber value may be low but when all values are considered the total may be quite high. The resource represents a real opportunity for integrated multiple use management as emphasized in several major legislative acts of the last fifteen years.

CONCLUSIONS

Although the application of the guidelines was limited in scope, it did indicate that they could be useful to determine:

1) what uses the aspen has in an area.
2) where the areas are located that are most suitable for certain uses and how they are described.
3) what alternatives may be applied to these areas given suitability for certain uses.

The approach has further merit in that it necessitates describing which characteristics are important to determining uses. This, in itself, is an exercise which benefits the manager's decision making process. What may have been a subjective process before now follows a clear pattern and allows easy communication of one's views. There may be disagreement as to what factors are most important to determining the suitability of aspen for various uses. This approach provides a format for discussion of these very important points. Further, the format, that of describing uses, stand-site characteristics and prescriptions provides an excellent means of consolidating research information. It is a logical separation of key areas which facilitates the dissemination of research results for field application.

In answering the question, "How do we manage the aspen?" the aspects studied here must be coupled with the total resource management situation. Aspen management direction can only be developed through systematic consideration of all the natural resources, demands and multiple goals for the entire unit, forest or region. The information provided by this approach can play a significant role in constructing these integrated resource management plans.

The aspen represents a tremendous resource capable of generating significant multiple benefits. Its management requires the application of research results in several key areas. Certainly those mentioned--uses, stand-site characteristics and prescriptions--need continuing work to increase our knowledge of the resource. The future management of the aspen will rely on the application of these results to help provide for selecting the best management program.

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Applying Research Information To Aspen Management Decisions— — State And Private Lands[1]

Thomas J. Loring[2/]

Abstract.--Any management decisions relating to State or private lands must fit within the constraints of the owner's or manager's purpose and objectives of management. If one of these objectives is maintaining tree growth on forested lands, proper harvesting and utilization is one method to consider. Research results can be useful.

Owner's Objectives

Public Use

Usually means multiple use in some form or other, depending on agency responsible, for example:

Game Department: Wildlife, watershed, recreation, timber production.
State Parks: Usually recreation, possibly watershed, wildlife.
State Forestry: Usually conversion to conifers for timber production.
State Land Department: Often based for single use such as grazing, hunting, mining.

Private

Objectives of owners are changing; recreation, range and wildlife, timber. Often single use on portions. Users often restricted. Could even be complete non-use.

Commercial Use

Most frequently timber production, often as a stage in conversion to conifers. Usually combined with range and wildlife.

Possibly as firebreaks, may include watershed and recreation.

Stand Management and Regeneration

Management for What?

Different objectives call for different management. These changes may be due to Agency policy changes or change of ownership. Aspen stands are not alone in this, though it may be emphasized in the Rockies due to esthetic interests.

Harvesting for What?

Sawtimber-Fiber: Yields up to 9,000 board feet/acre at 50 years on good sites have been reported. This would be possible in pure stands only but is probably not very common in the Rockies. Where there is a good market for sawn products or veneer, aspen sawtimber can more than pay its way. While the market is not too good, a fiber market is also needed to develop enough recovery from the harvesting operation.

Roundwood

Including pulpwood, mine timbers, and fuel items, may also be a feasible product where markets can be developed.

Stand Regeneration

Or in some cases stand conversion to other species or improved strains of aspen might be another reason for harvesting aspen stands.

Regeneration Studies

Researchers have found that aspen clones vary greatly in growth rate and stem form,

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[1/] Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

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indicating that, under intensive management, selection of native varieties to favor the outstanding clones could be well worthwhile.

Natural hybrids have been reported from various locations throughout the range of aspen. These hybrids occur between "Quakes" and Bigtooth, and between both of them and white poplar (P. alba). Hybrids with European species show considerable promise in both growth rates and quality (Church 1963, Pauley et al. 1963, Einspahr and Benson 1964). There is potential here for developing strains capable of fully utilizing our good sites, producing high quality wood on a short rotation.

Regeneration studies dealing with aspen, seeding, the use of cuttings and seedlings appear to warrant more attention. Perhaps we should be planting aspen as a nurse crop on burns and bug-killed areas in the mixed conifer and spruce zones.

Product Research

Other portions of this symposium are dealing specifically with product research and research needs related to aspen. Let me just mention here that a land manager may want to consider a range of products including:

Established items (pallets)
New items (Shakes)
Primary products (Lumber)
Secondary products (Molding)
By-products (Shavings)

Environmental Studies

The role of Rocky Mountain aspen in the overall environment of a given stand or ecosystem tends to be ignored, misunderstood, or misinterpreted, depending on the interests and background of the observer. The cattle rancher likes the open stands for the available forage under them; the sheep herder considers only the browse available to his sheep from this year's sprouts. The Sierra Clubber wants to retain that colorful view. The fire control officer uses aspen stands as firebreaks. The timber manager plans to convert it to conifers.

Perhaps now is the time for all of these different viewpoints and considerations to be brought together in some environmental studies to assist the land manager in deciding what to do with his aspen stands.

In my opinion, the private landowner, usually operating under fewer constraints than the agency land manager, and with his overriding need to make each operation for itself, should be the prime mover in implementation of research results related to aspen management. After all, any tree species that you can harvest for sawlogs at 60-80 years of age offers a quicker economic return than one that must be 120 years old.

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Applying Aspen Research To Industry[1]

Lorin D. Porter[2]

Abstract.--By applying research to our management decisions, we can penetrate enough markets that the demand for our aspen will increase, causing the price to increase to a point that it can become profitable for us to continue manufacturing aspen.

We, at Western Pine Industries, have been forced to examine the research available concerning aspen because at our Chama, New Mexico operation our supply of timber is made up of about 25 to 40% aspen.

Some aspen research information which has been valuable to us is the research concerning the various uses of the product (Pallet material, furniture core, construction strength and acceptance to builders.) We have sold aspen to each of these markets and plan to continue to sell to these markets in the future. Research which has been especially helpful to us in penetrating the furniture market is the research done in the area of aspen drying. From the aspen drying research we learned how to dry the material so that it will remain straight after being ripped into narrow strips (approx. 1" x 1-1/2" x 4') which can be used by furniture manufacturers only if they are straight.

Another market in which research has helped us make decisions is our market for aspen paneling. Much of the upper grade paneling is used for paneling which is a beautiful product. This product also needs special drying attention to be sure it remains marketable after drying.

Finally we are exploring a market which through research and development may have great potential for aspen. This is the shingle or roofing market. At this time, it is in the experimental stage and we are not sure what the ultimate market will be, but we are encouraged with the results thus far.

In summary, we feel that by applying research to our management decisions we will be able to penetrate enough markets that the demand for our aspen will increase, causing the price to increase to a point that it can become profitable for us to continue manufacturing aspen.

1/ Paper presented at the symposium on Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains, Ft. Collins, Colorado, Sept. 8-9, 1976.

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Symposium Summary

William R. Wilcox[1]/

It is a difficult job and rather dubious honor to be called on to summarize the lively discussions of this symposium. I'm not sure I know how to do it, particularly since it will be recorded for posterity in the proceedings.

I think it is first necessary to reexamine the stated purpose as set forth in the announcement of the symposium. "The purposes of this symposium are to bring available information on western aspen utilization into focus, and to explore the potential for improved management through increased marketing opportunities."

Did we accomplish these purposes for the entire 4.1 million acres of commercial aspen in the Rocky Mountains? My answer is "No, I don't think so." The key word is focus. While we have succeeded in focusing on some specific utilization opportunities, we can see that they are only a start in terms of what will be needed to solve the aspen manager's problems. The extent of utilization needs will not be fully resolved until management prescriptions are more thoroughly developed. And as Bruce Hronek stated, "We land managers are very confused about aspen."

As brought out in the discussion by John Jones and Don Perala, there is a real problem as to whether managers should thin or not thin aspen stands. Another question raised by Bud Hittenrauch, is whether to clearcut or not. Still another is what should the rotation age be for Rocky Mountain aspen? Most speakers talked in terms of 80 years, but when a member of the audience asked the question, "Why 80 years?", there was no specific answer. The question of increased or decreased forage production immediately after harvest could not be definitely settled either.

While these are management questions beyond the scope of this symposium, it is obvious that they are fundamental to finding utilization solutions. Therefore, perhaps we should ask, "Have we really focused on production and marketing opportunities?"

One marketing aspect was quickly and simply, yet dramatically, summed up by Keith Runyon: "I'm as confused about what to do with aspen lumber as you are about harvesting it. We sell it to get it the hell out of the yard." He also added that the marketing of aspen should be planned before the tree is cut, not just left to chance. Yet Lonnie Porter of Western Pine Sales reported success in coping with this same problem.

Most of the other utilization speakers spoke along the same general theme of "the tremendous opportunity that aspen presents." We heard of at least 50 opportunities, but one unusual product that sticks in my mind was a search by a Japanese firm for 20 million board feet per year to be used in chopsticks. It doesn't cost any of us much to speak in glowing terms of opportunities. But the moment of truth comes for you in industry when you decide about investing the dollars required to produce and market aspen products. For forest managers, it's a question of deciding how much of your scarce operating collars you're going to put into aspen management. Did our discussions here help you make those decisions?

For the other stated purpose of the symposium--"to explore the potential for improved management through increased marketing opportunities"--I could repeat another equally discouraging list of things we didn't accomplish. But I will limit my comments to Dave Betters' report on the tremendous diversity he found in aspen ecosystems on one national forest--the Routt--demonstrating just how far both researchers and managers still have to go in learning how to manage this species.

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Throughout this symposium, I heard considerable buck-passing between an about equally divided group of land managers and wood utilization people. The utilization people say there are tremendous opportunities if the land managers would just make the timber available. Otherwise a tremendous resource will be allowed to waste away on the stump. Similarly, I heard management people say we want to do something, but there are no markets. One very specific statement I heard, "They (meaning processors) have to take out the aspen component in our sales, but I don't know what they do with it and don't care." Or, finally, the managers and processors both say, "Sure, here are all these tremendous market potentials but not a single one is economical." This kind of buck-passing obviously won't get us anywhere.

First I said, "No, we didn't accomplish the stated purposes of the meeting," and now I've even questioned the purposes. But this doesn't mean the symposium wasn't worthwhile. Far from it.

We did accomplish at least one important thing in the last two days. We have started talking together on the aspen situation as land managers, utilization specialists, and industry. We recognize our shortcomings--"our great pool of ignorance" as Norb DeByle put it--but at least we have made a start. This is a very, very positive accomplishment as far as I'm concerned. There is hope because, as Dave Lowery stated, "Today's Rocky Mountain aspen problems and opportunities are the same set of problems that our Canadian neighbors and the Lake States faced 5 to 10 years ago." They are well on their way to a solution and so are we. We have taken that first step, and I think one man has had a lot to do with getting us started. I would like to close by leading a round of applause for that man--Gene Wengert--whose research provided the impetus for the Symposium and who took the lead in developing the program.

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Uncontrolled wildfire, which used to assure regeneration of Rocky Mountain aspen, is no longer socially acceptable. Harvesting is therefore necessary to prevent this unique forest type from reverting to coniferous forest. The status of our knowledge about utilization as a tool in aspen management is summarized in 33 papers in five areas: perspectives on Rocky Mountain aspen resource, aspen ecology and harvesting responses, market opportunities and limitations, research advances in aspen utilization, and applying research information to aspen management decisions.

Keywords: Aspen management, aspen symposium.

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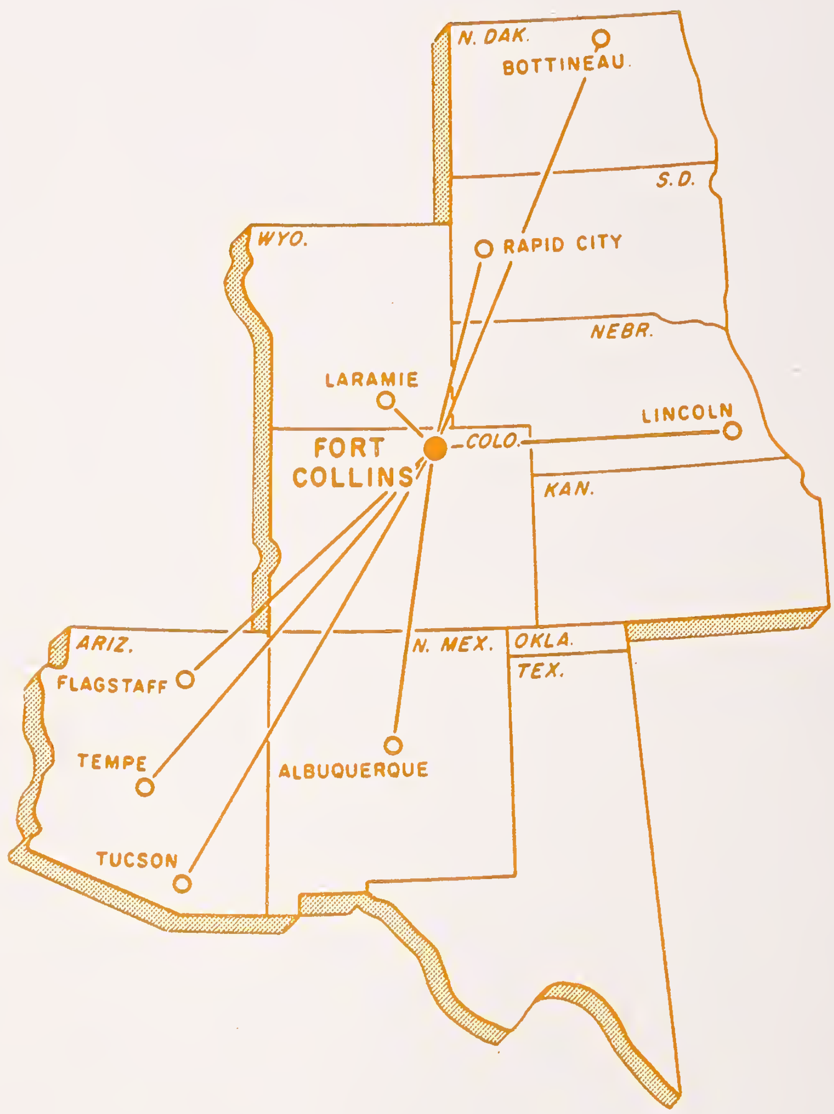
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